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SOLVING PROBLEM OF MOVING MINING SUPPLIES INTO THE BACK COUNTRY OF AUSTRALIA BY MAKING USE OF CAMEL TEAMS

The Air Giant on the Dinner Table
James H. Collins

North Africa Important Source of Phosphate Rock
A. Grenon and A. S. Taylor

Driving First Tunnel Through Continental Divide
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A Great Hydro-Electric Project in Newfoundland
A. A. Paoli and F. A. McLean

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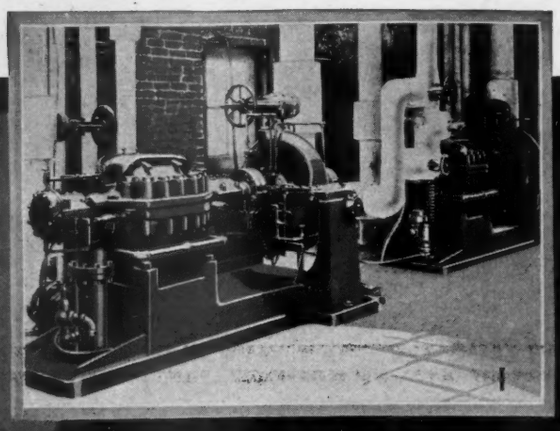

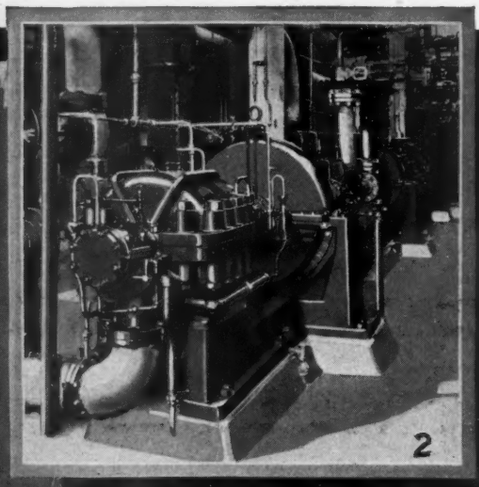

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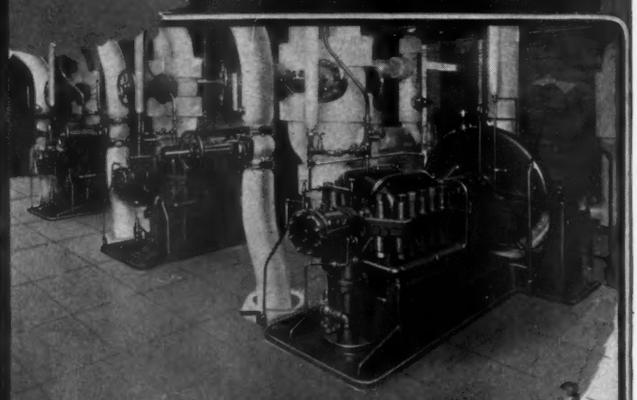

1. *Two of the four Cameron High-Pressure Boiler Feed Pumps at the Pineville plant of the Kentucky Utilities Company.*
2. *At the Devon plant of the Connecticut Light & Power Company three Cameron High-Pressure Pumps serve the boilers.*
3. *These three Cameron Pumps are on boiler feed service in a large mid-western central station.*

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Putting Through a Great Hydro-Electric Project in Newfoundland

Developments in Humber Valley Mark an Industrial Expansion of Momentous Significance

By A. A. PAOLI and F. A. McLEAN

THE MODERN tendency to substitute power-driven machinery for hand labor wherever possible has made large blocks of low-priced power essential to industrial development; and, as a result, Canada, the United States, France, Italy, Switzerland, Australia, and other countries are devoting their efforts to the exploitation of their water-power resources.

Among the important projects of this kind now underway is the Humber Valley Hydro-Electric Development in Newfoundland. Though by no means as large from the standpoint of total available horse-power as some other developments in progress, this undertaking is noteworthy on account of the influence it will have on the future of Newfoundland. To the engineer, this job is of interest mainly because of the speed with which it has been pushed forward by reason of the use of oil engines, portable compressors, and labor-saving equipment.

Interesting as the history of Newfoundland is from the day of its discovery by John Cabot, in 1497, down to within recent times, still it is not possible to dwell upon this aspect of her past. Succeeding centuries added more and more to her industrial and commercial importance; and today we find this section of the Dominion of Canada enjoying an economic position little dreamed of by the hardy people that formed her first settlers and that for generations depended upon the neighboring fisheries as a source of livelihood.

What Gibraltar is to the dominance of the Mediterranean, Newfoundland is to the defense of the Dominion, standing as this great island does at the parting of the ways of navigable waters leading into the very heart of Canada. Newfoundland covers an area of 42,734 square miles; and her population has increased from 98,000 in 1845 to about 265,000 in 1921, when the last census was taken. In 1831, her exports of fish were valued at $220,000, while during the fiscal year ending June 30, 1923, fish worth $10,000,000 were shipped out of the country. In the same year the imports of general merchandise amounted to $19,500,000.

NEWFOUNDLAND in the past has offered but few inducements to her youthful citizens to remain at home; and because of this thousands of them have emigrated to wider fields in search of profitable and agreeable employment.

Recent industrial developments, increased attention to Newfoundland's mineral resources, and other activities are now giving the country a stronger appeal to her native born by opening to them new avenues to lucrative service.

The present article deals with a huge and many-sided industrial development that called for an army of 3,000 workers; that has cost more than $20,000,000; and which will give permanent employment to a still larger number when the fullest use is made of the electric power about to become available.

While fishing has long been the principal industry of Newfoundland, great strides have been made in recent years in developing her mineral wealth and in establishing a pulp and paper industry. In fact, iron ore from the mines on Belle Isle has made possible the great plants of the British Empire Steel Corporation at Sydney, N. S. The island has also yielded some copper, while considerable exploratory work on galena, lead, and coal lands is well underway. An area of bituminous shale, estimated at 150 square miles, has been discovered on the west coast; and, a short distance to the north, boring operations for petroleum are being carried on. At Grand Falls, on the Exploit River, stands the plant of the Anglo-Newfoundland Development Company, Ltd., producing 300 tons of newsprint daily. Several smaller plants are also operating. On the Humber River, at Corner Brook, the big hydro-electric undertaknig of the Armstrong-Whitworth interests is now nearing completion; and this brings us to the purpose of our story.

This great project, known as the Humber Valley Hydro-Electric Development, involves the construction of a canal 8 miles long; of several miles of railroad; of large concrete and earth dams; of 2,300 feet of railway trestle; of a large power house and transmission lines; of a 400-ton paper mill; and of a model town and other structures. With the completion of the work, in July of this year, the natural resources of the west coast of Newfoundland will be opened up for the benefit of the people. Thousands of acres of spruce and fir, valuable for paper making, will be made accessible; and in order to assure an inexhaustible supply of pulpwood for the local paper factories a policy of reforestation will be enforced.

Operations were started in the summer of 1923, and they began with the clearing of a strip of land, 8 miles long and 350 feet wide, extending along the line of the canal; with the clearing of a 350-foot strip 4,000 feet long for the penstocks; and with the clearing of a large section at the Deer Lake end of the canal where the control system for the water entering the penstocks is situated. It was also necessary to remove the timber and brush from a large area of land at the upper end of Deer Lake for the purpose of flooding it and for the erection of a power house.

The contract for the canal was sublet to the Northern Construction Company. It covered a waterway, 125 feet wide at the bottom and 8 miles long, between Grand and Deer Lakes

and two earthwork embankments at Glide Brook. These fills are 4,000 feet long by 35 feet high and 950 feet long by 75 feet high, respectively, and are made from the material excavated from the canal. By building these embankments it was possible to shorten the waterway by about 2½ miles. The depth of the material removed from the canal varied from grade to 53 feet, and a total of 4,000,000 cubic yards—consisting of muskeg, hardpan, boulders of granite, and ledges of sandstone and shale—was excavated.

To expedite the removal of this enormous quantity of material the Northern Construction Company employed eight Bucyrus drag-line excavators having capacities of 1, 3½ and 6 cubic yards. For drilling the hardpan and ledges of rock, preparatory to blasting, the contractors used Keystone portable well drills aided by Ingersoll-Rand "Jackhamers" and portable compressors, while the pop holing of boulders along the right of way and the drilling of rock encountered in grading the canal bottom were done with DCR-23 "Jackhamers." The ease with which the compressors were moved from place to place and their capacity to stand up under hard service made them especially valuable for this class of work. In other words, they made it possible to drill and to blast the rock so that this work could always be kept well ahead of the drag-line excavators. Owing to the size of the excavators it was necessary to dismantle them for shipment to Newfoundland, to reassemble them on the job, and to dismantle them again for return shipment. Portable compressors operating No. 90 riveting hammers facilitated this operation. For driving out the rivets the hammers were fitted with rivet busters and safety releases.

As a result of building the huge dam, Grand Lake, originally 130 square miles in extent, now covers 150 square miles. The catchment area of this lake embraces 1,650 square miles and gives an annual average flow of 5,000 cubic-foot-seconds. The storage space thus provided, amounting to 30,000,000,000 cubic feet, will assure a continuous flow of 4,000 cubic-foot-seconds. The outlet from Grand Lake was originally by way of Junction River into Deer Lake, which lies at an elevation of 110 feet. The natural difference in level between these two lakes is 236 feet, and this has been increased by the impounding dam.

The W. I. Bishop Company, constructing engineers of Montreal, was responsible for the design and the building of the dam across Junction Brook. This dam raises the level of Grand Lake 27 feet and permits the surplus water to flow by way of the old channel. The main canal takes off from the lake at a point about two miles west of the dam. To facilitate the erection of the main dam, a temporary crib cofferdam was constructed some distance upstream at a point where the Junction River leaves the lake—thus diverting the water from the dam site. This cofferdam consisted of a central section, made up of alternate cribs and sluices, and of two wing dams each of which had a sheet-piling core and rubble slopes. There were 22 piers and 21 sluices, each 15 feet wide. The sluices were fitted with stop-logs to hold back the waters of Junction Brook when working on the foundation of the main dam.

The main dam is of the Ambursen hollow type; is about 1,000 feet long and 75 feet high; and contains approximately 28,000 cubic yards of concrete. Its construction necessitated the diversion of the Newfoundland Government Railway for a short distance from Port-aux-Basques to St. John's. The line now crosses the Junction River by way of the crest of the dam—thus avoiding the erection of a special bridge. A spillway in the dam, consisting of 18 electrically operated gates each of which is 15 feet wide, provides for a maximum discharge during flood periods of 26,000 cubic-foot-seconds.

Stone for coarse aggregate for the necessary concrete was supplied from a quarry opened for the purpose by Fraser, Brace, Ltd., who built the intake, forebay, and power house. This quarry was furnished operating air by an Imperial Type "X" compressor, belted to a 115-H.P. oil engine; and a Canadian Ingersoll-Rand Class "ER-2", tandem, compound compressor, driven by a 75-H.P. oil engine, supplied air to numerous "Jackhamers" engaged on this part of the project. All the steels that were used in this as well as other quarries providing rock for different purposes were kept in condition by two No. 550 "Leyner" sharpeners and a "Leyner" oil furnace. A 5x5-inch portable compressor, employed about the dam, was later shipped to Corner Brook for use on caisson and sewer work. Oil engines also provided power for most of the equipment in the rock-crushing and screening plant—in fact, both portable compressors and

Top—How the main dam looked in April of 1924. Left—Close-up of the main dam viewed from the downstream side. Right—Temporary dam, across Junction Brook, built to divert the stream while constructing buttress foundations for the main dam.

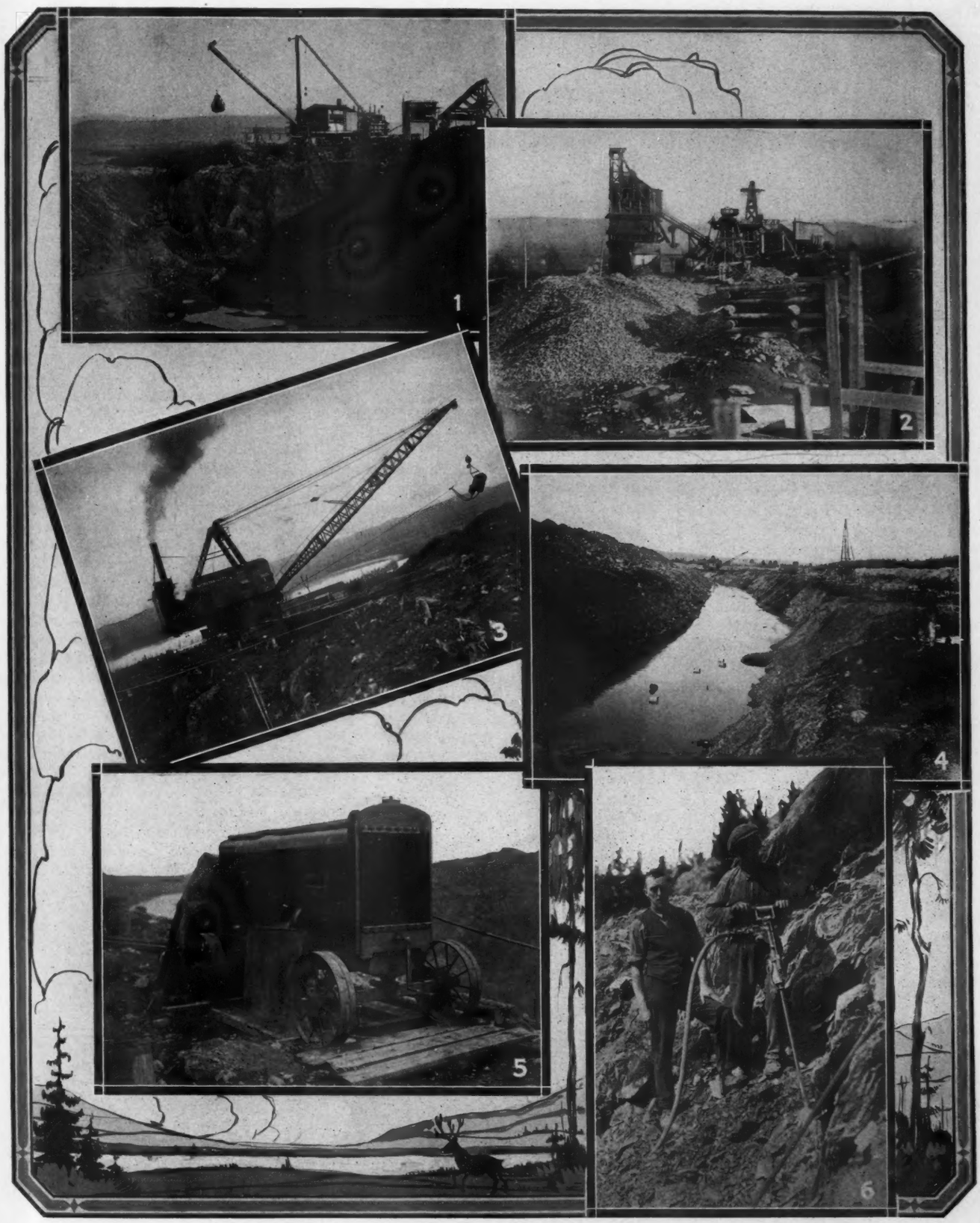


Fig. 1—Sand pit on South Brook from which aggregate was obtained for the concrete used in building the dam and the power house.
Fig. 2—Stone-crushing plant at South Brook quarry where the crushing machinery and the air compressors were driven by oil engines.
Fig. 3—Big drag-line excavators made quick work of the job of digging the canal.
Fig. 4—Stretch of the 8-mile canal which carries water from Grand Lake to the forebay of the power house.
Fig. 5—One of the many portable air compressors in service on the Humber Valley Hydro-Electric Development.
Fig. 6—"Jackhamers" have been used at the town-site quarry at Corner Brook in getting out stone for the construction of a macadam road.

The upper sections of these 4,000-foot penstocks are formed of wooden staves held together by steel hoops while the lower sections, which are subjected to higher pressures, are of steel-plate construction.

oil engines were employed to a notable extent on this undertaking.

Water for the power plant is conveyed from Grand Lake to the forebay by way of the canal. Intake regulating works are located in the easternmost of the two sections into which the canal is divided. This intake consists of five sluice gates. Each of these gates is 22 feet wide and 15 feet high and is fitted with two bronze screws operated by an electric motor or by independent hand gear, the latter for use in case of emergency.

The forebay is situated at the downstream end of the western section of the canal; and its seven sluices, each 12 feet square, control the flow of water to the pipe lines. The sluice gates are of steel; are fitted with rollers and bronze rubbing strips; and each is opened and closed by a single screw rotated by means of an electric motor. Portable hand gear is also available. Ice is prevented from entering the penstocks by overhanging curtain walls and by steel trash racks.

Seven penstocks carry the water from the forebay to the power house, 260 feet below; but provision has been made for two additional pipe lines, should they be required later on. Each penstock is provided with automatic trip gear which becomes operative when the velocity of the water in the pipe exceeds a prescribed speed. The upper 2,500 feet of each of the 4,000-foot penstocks, down to the point where the water has a head of 170 feet, is of wood-stave construction and has an internal diameter of 9 feet 6 inches. The remaining lower section—of riveted steel plate—tapers from a diameter of 9 feet 6 inches at the uppermost end to 8 feet 6 inches at the bottom. A total of 150,000 cubic feet of timber and 2,000 tons of steel bands were used in building the wood-stave portions of the penstocks. Pneumatic woodborers and wrenches were employed to speed up the assembling of the wooden sections, while air-operated riveting hammers and drills helped to put the steel units together. Ingersoll-Rand close-quarter drills, with special sockets to fit the nuts, served to tighten the nuts on the hoops encircling the wooden piping. Air for all of these tools was supplied by portable compressors.

The intake control, as previously mentioned, consists of a 5-gate sluice dam across the canal. The usual headworks include a concrete spillway, 150 feet long, to take care of excess water. To guard against surges and to provide further control, automatic in action, two 25x10-foot Stauwerke gates have been installed. At this point there is also a 30-foot ice chute and a 4,000-foot steel-lined log chute for conveying the river-driven logs from the canal to Deer Lake, whence they go to the paper mill at Corner Brook. The difference in elevation between the forebay and the tailrace is 263 feet.

Attractive Glynn Mill Inn, a 65-room hotel, which is owned and operated by the Newfoundland Power & Paper Company for the convenience of members of its staff and of visitors.

At the southeast corner of Deer Lake there has been constructed a typically modern power house which will be capable of developing well over 100,000 H. P. The largest share of this block of electric energy will be delivered to the paper mill at Corner Brook, 30 miles away, where steam will be generated by electricity. Surplus power, however, will be available and may lead to the exploitation of important copper deposits near the mill site.

The power-plant equipment consists in the main of seven 10,250-kilowatt alternating-current generators, each driven by a Francis turbine designed to develop 14,000 B.H.P. at 375 revolutions per minute under a head of 250 feet. According to model tests, the turbines are expected to be at least 91 per cent. efficient. The shafts of all the units will be placed in a single line and parallel with the length of the power house.

By reason of the severe conditions under which each turbo-generator set will have to operate—that is, at the end of a 4,000-foot penstock and under a head of 250 feet—it was deemed desirable to stabilize each set by interposing a 20-ton fly-wheel, 12 feet in diameter, between the turbine and its associate generator. This procedure is unusual, but had to be resorted to because it was not feasible to employ a suitably placed surge tank.

Current will be generated at the power plant at 6,000 volts and this will be stepped up by suitable transformers to 66,000 volts for transmission to the paper-mill substation at Corner Brook. In placing the two rows of towers for the 30-odd mile transmission line.

air-driven tools made relatively short work of digging the holes, pop holing, riveting, etc., that had to be done in connection with this part of the project. The 5x5-inch portable compressors, of Ingersoll-Rand make, that supplied the air on this job were easily moved ahead as the work progressed.

At the substation, the 66,000-volt current is stepped down to 4,400 volts for the electric steam generators in the paper mill; to 2,200 volts for nine 2,600-H.P. synchronous motors that operate as many pulp grinders; and to 550 volts for lighting and for other purposes at the mill. The substation is also equipped with a 500-H.P. Diesel-engine-driven generator set for standby purposes. This unit is capable of lighting the mill and the town, of running the repair shops at the mill, etc., etc.

This brings us to the paper mill of the Newfoundland Power and Paper Company, at Corner Brook, which covers about 12½ acres and is built on reclaimed ground made up of several hundred wooden piles and 500,000 cubic yards of earth fill. When ready for operating this mill will produce annually 120,000 tons of newsprint requiring about 200,000 cords of pulpwood. The mill is so situated that wood can be received at the plant in the form of river-driven logs, 12 to 16 feet long, or in 4-foot lengths shipped either by rail or by water. As a matter of fact, Corner Brook is on the main line of the government railroad and in direct steamship communication with Montreal, New York and European ports.

To impound the river-driven timber and to prevent it being washed into the open sea a boom was constructed by the W. I. Bishop Company and anchored to a number of rock-filled cribs. Large pieces of rock for ballasting these cribs were quarried near by; and, owing to the steepness of the rocky bank, the compressor—a 5x5-inch Type Twenty portable—was loaded on a scow and brought alongside the quarry. A 150-foot length of hose was then run up to the two "Jackhamers" used for drilling the rock previous to blasting.

Penstocks, power house, and Deer Lake seen from aloft. The penstocks are supported by numerous concrete cradles built at right angles to the pipe lines.

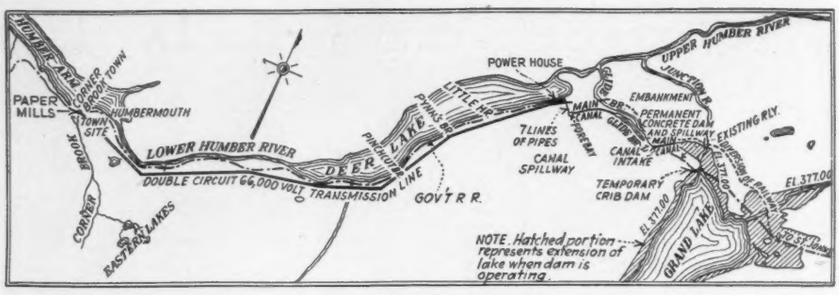
Much as we should like to describe the paper mill in its entirety, it is impossible to do so within the space available, as this article has mainly to do with the broad aspects of the Humber Valley Hydro-electric Development. However, we might mention here that the plant is expected to begin manufacturing paper this month—about two years from the time work on the project was started. This certainly is a record, considering the magnitude of the undertaking.

The fine progress made was due in no small measure to the extensive use of compressed air equipment; and one of the engineers, in charge of the work for the G. W. Armstrong-Whitworth Company, had this to say of the numerous portable units on the job. "Our plant in Newfoundland consisted mainly of portable compressors, and the service we got from them has rendered me an absolute convert to this equipment. This type of plant is not only low in first cost but also has the highest resale value. It saves all expense for a building and foundations, and is ready to run as soon as it gets to the job."

The last phase of this momentous project has involved the creating of a town capable of housing a population of from 7,000 to 8,000 people. This village, laid out by Mr. Thomas Adams of the Canadian Government Town Planning Department, is arranged with a view to future expansion, and is up to date in every respect. So far, 100 attractive cottages have been erected, together with a 65-room hotel and various public and administrative buildings.

In this work of community building, portable compressors and pneumatic tools were found of great aid in quarrying rock for roads; in digging trenches for water mains and a sewerage system; in excavating for the foundations of buildings; and in painting some of the finished structures by means of paint-spray outfits. An interesting application of compressed air was in connection with the calking

How the town of Corner Brook appeared less than a year after work was started on the big paper mill.



Territory covered by the Humber Valley Hydro-electric Development and the principal features of this great undertaking.

of joints in the sewer where it empties into the Bay of Islands. For this work a 5x5-inch portable, carried by a scow, was employed to provide compressed air for calking hammers used effectively by divers at a depth of twenty feet below the surface of the water.

Five of the portable compressors utilized on this great undertaking, and which have been shifted from point to point as the work progressed, are the property of the Newfoundland Power & Paper Company, and they will be employed for maintenance and repair work in the mill and about the town of Corner Brook when they are no longer needed to put the finishing touches on the Humber Valley Hydro-electric project.

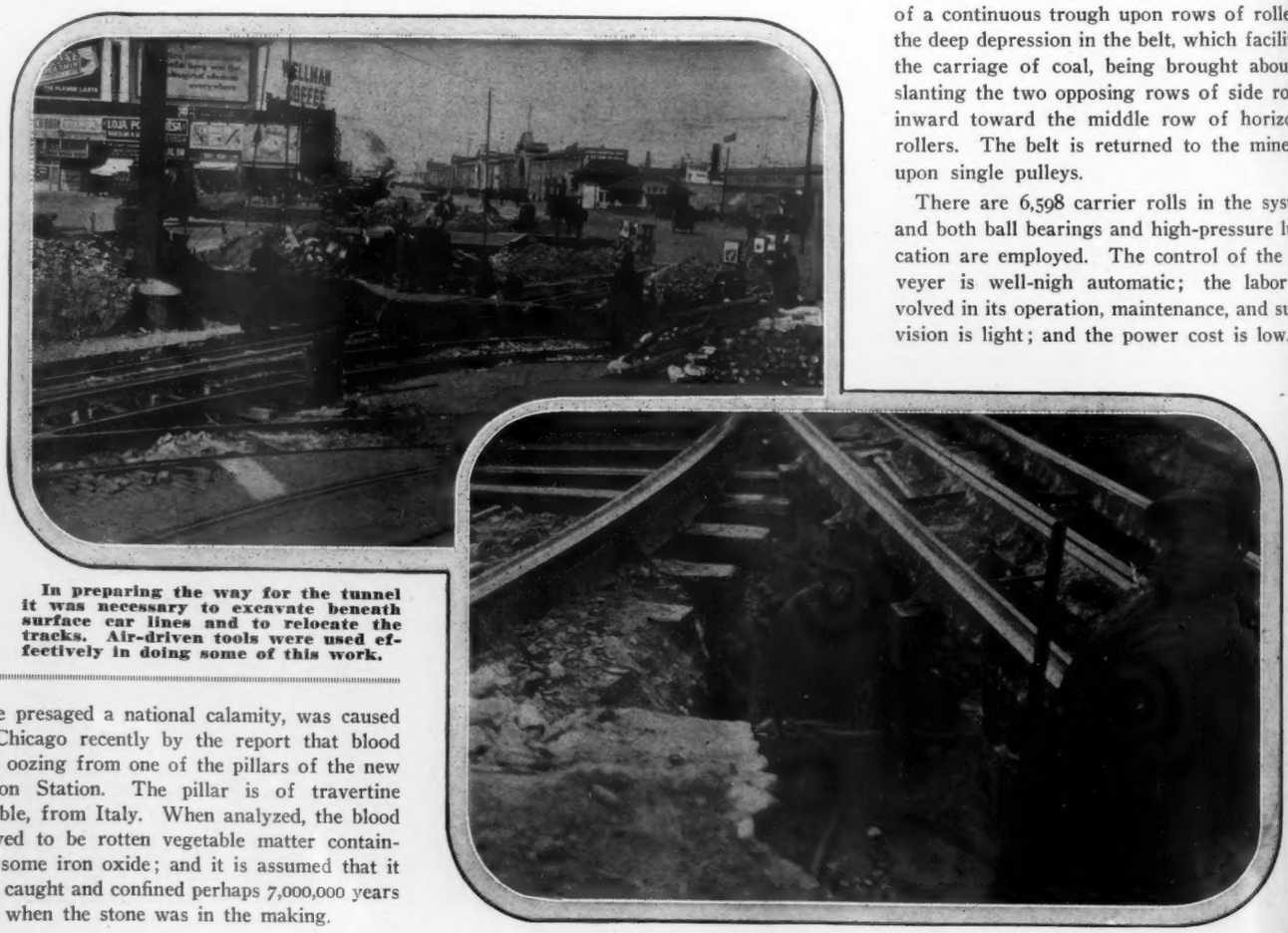
A mild sensation, which in olden times might have presaged a national calamity, was caused in Chicago recently by the report that blood was oozing from one of the pillars of the new Union Station. The pillar is of travertine marble, from Italy. When analyzed, the blood proved to be rotten vegetable matter containing some iron oxide; and it is assumed that it was caught and confined perhaps 7,000,000 years ago when the stone was in the making.

SUBWAY TO LESSEN TRAFFIC CONGESTION

THE new subway which intersects the Embarcadero at the foot of Market Street in San Francisco, Cal., is designed to lessen to a large extent traffic congestion which has prevailed at certain hours in the neighborhood of the Ferry Building. This subway will be finished in the near future and will be used entirely by vehicular traffic, thus leaving the thoroughfare above to street cars and pedestrians.

At this point, in the past, street-car movement has been arrested on an average of 4 hours and 48 minutes during the 11-hour period between 7 a. m. and 6 p. m. On the other hand, vehicular traffic at the ferry loop has been checked a total of 6 hours and 12 minutes during this same interval. In other words, a serious loss has been imposed upon everyone concerned.

The subway starts on an incline just north of Mission Street at the Embarcadero and descends on a grade of approximately 4 per cent., passing under the ferry loop and reaching the surface again at the foot of Merchant Street. The roadway is 23 feet wide, sufficient for one line of traffic in each direction, and with ample room for the widest trucks to pass. The minimum clearance overhead is 12 feet. Air-driven tools and a portable compressor have been of material service in speeding up this work which had to be pushed along with all practicable dispatch.



In preparing the way for the tunnel it was necessary to excavate beneath surface car lines and to relocate the tracks. Air-driven tools were used effectively in doing some of this work.

GREAT BELT CONVEYER

WHAT is said to be the longest belt-conveyer system in the world is in successful operation in a tunnel connecting a coal mine of the H. C. Frick Company with the Monongahela River. This conveyer is 4¼ miles long, and carries upwards of 9,000 tons a day. It was originally planned to use cars for transportation; but when it was found that 4,000 would be required to give adequate service the belt conveyer was decided upon.

From the colliery the belt runs in the form of a continuous trough upon rows of rollers—the deep depression in the belt, which facilitates the carriage of coal, being brought about by slanting the two opposing rows of side rollers inward toward the middle row of horizontal rollers. The belt is returned to the mine flat upon single pulleys.

There are 6,598 carrier rolls in the system; and both ball bearings and high-pressure lubrication are employed. The control of the conveyer is well-nigh automatic; the labor involved in its operation, maintenance, and supervision is light; and the power cost is low.

Driving First Tunnel Through the Continental Divide

Reasons for Notable Progress Made at the East Portal

By ROBERT G. SKERRETT

PART IV

SOUTH Boulder Creek Canyon, from which the east end of the Moffat Tunnel enters the mountain, was fashioned when the Master Builder was in an austere mood, and the neighboring valley has apparently lost little of its harsh aspect during the long ages that have intervened. Down this great rock-ribbed funnel the winds sweep with violence and frequency from the towering heights of the Continental Divide; and the gales are but slightly tempered by the rather thin stands of timber which interpose on the lower slopes.

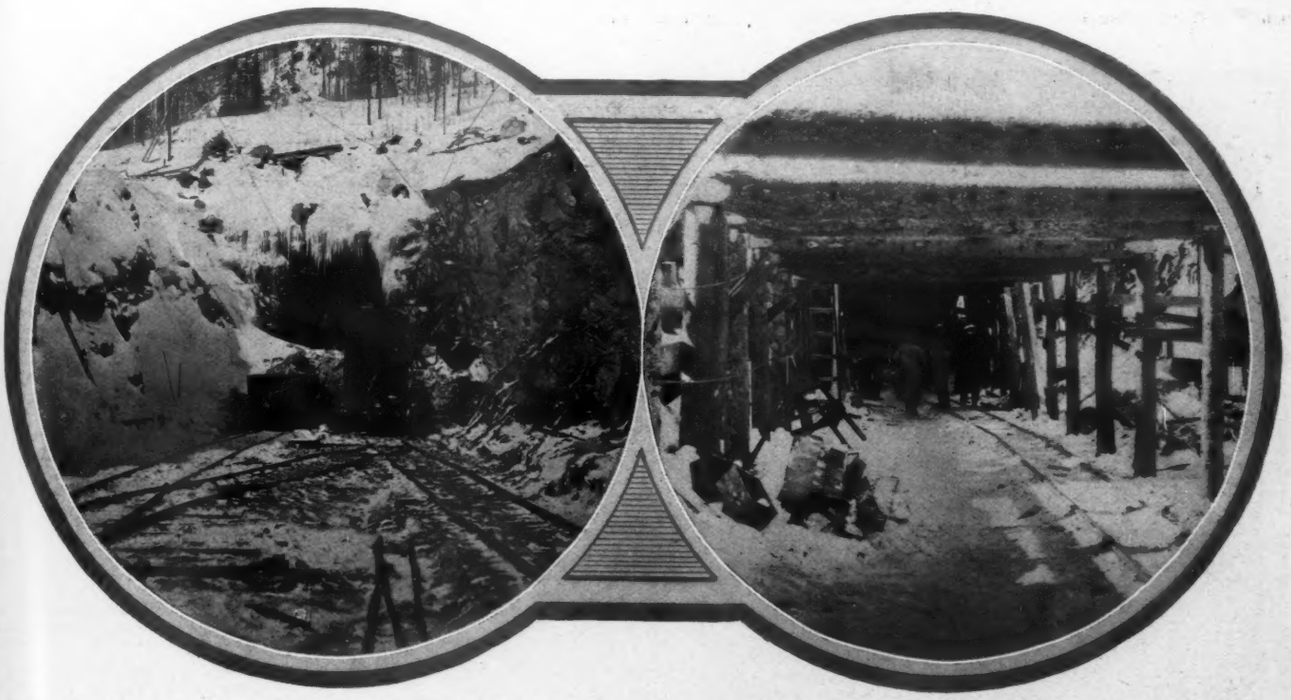
The east-portal camp is set at the head of this canyon and is exposed for the most part to the full force of the angry elements. Weather conditions are, therefore, both rigorous and tempestuous during quite seven months of the year. Even so, Nature has offered some compensations for this forbidding setting, and one of these is the hardness of the rock that outcrops at that point and which has been encountered well-nigh continually as the tunnel drivers have advanced the headings deeper and deeper into the granite backbone of the range. By reason of air-driven rock drills of exceptional power it has been possible for the workers on the east side to forge ahead faster than has been practicable at the west side where the rock, for the most part, has been decidedly soft and easy to drill.

IN THIS concluding installment of the series covering progress on the Moffat Tunnel attention is directed especially to operations at the east portal where the contractor has been able to push ahead with commendable speed largely because of the nature of the rock encountered and because of the equipment at his disposal.

Despite a heavy and hampering inflow of water which started on February 15, the headings at the east side have been advanced at a gratifying rate since our preceding number was printed. According to the information now available, the status of the work at the east portal on March 12 was: Heading of water tunnel, 8,314 feet in; main heading, 8,287 feet in; and the railroad tunnel excavated to full size for a length of 5,078 feet.

Tunneling was started at the east portal during October of 1923—a short while after tunneling was begun at the west portal, and by the end of that month the water tunnel had been driven 75 feet. By the close of 1923, the water tunnel was 638 feet in, and the main or railroad-tunnel heading had penetrated the rock a matter of 26 feet. In fact, the east-side camp was the first to drive any part of the railroad tunnel. By the end of March, 1924, the east-side water tunnel had been driven 1,937 feet; the heading of the main tunnel was 1,285 feet in; and 30 feet of the railroad tunnel had been enlarged to full size. At that date, progress at the west side was represented by 2,187 feet of water tunnel and 510 feet of railroad tunnel—none of the enlargement of the main tunnel having been undertaken.

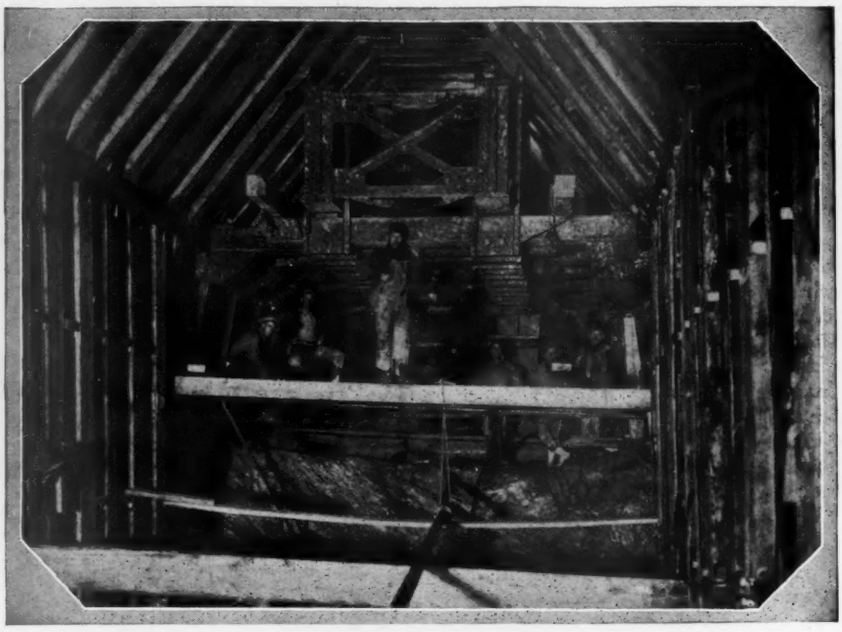
What has already been said about the power plant, the general facilities, and the accommodations for the personnel at the west portal also applies to the east portal, except that the working force at the east side is smaller—numbering about 260. Accordingly, we shall not touch upon these matters again. The east tunnel starts at Elevation 9,198, and the profile ascends on an easy 0.3 per cent. gradient. At mid-length—that is, 3.045 miles in—the crest of the tunnel will be at Elevation 9,241 feet,



Left—Portal of the main tunnel with an air-operated shovel clearing the open cut preliminary to work at the point of tunnel enlargement.
Right—Snowshed erected over the approach to the water tunnel at the east portal where drifting snow might otherwise have blocked operations.

representing a climb westward of 43 feet in that distance.

As we go to press, the east-side water tunnel has penetrated the mountain for a distance of 8,314 feet; the main heading is in 8,287 feet; and the railroad tunnel has been enlarged to full size for a length of 5,078 feet. The railroad-tunnel heading has recently reached a very hard quartzite granite which requires five hours to drill a round. Heavier drill steels are being substituted in an effort to deal more effectually with this hard rock. While this geological development adds considerably to the effort that must be expended in advancing the work, still the situation is interesting to the public because it shows that the tunnel drivers have probably reached the dense core of the Continental Divide.



Forward end of the Lewis, traveling, cantilever needle bar projecting beyond the bench and supporting the roof timbers while a part of the bench is being excavated preparatory to putting in the long, permanent, side-wall timbers.

In one of our previous installments we referred to bodies of water lying above the tunnel line in bowls formed by glacial action when the Rockies eons ago were covered with ice to a depth of 1,000 feet and more. On the east slope of the Continental Divide and adjacent to the tunnel there are a number of these lakes, known as Crater Lakes, and one of them was responsible a short while back for flooding a considerable section of the tunnel. This occurred on February 15, when the east-side water-tunnel heading was about 8,050 feet in. At that time a 6-foot seam in the rock was exposed, and from it suddenly gushed water at the rate of 1,800 gallons a minute, or 450 tons an hour. This water came from Lower Crater Lake, and for a while the inundation slowed up progress.

In the course of a month the flow diminished to 150 gallons a minute; and the gradient of the tunnel has made it comparatively easy to drain the water to the portal by the ditches flanking the tracks of the mucking railway. The supposition is that Lower Crater Lake will probably be found empty when weather conditions make it possible to reach that part of the overlying mountain. With the exception of this troublesome seam, the rock in the water tunnel has been generally solid. This is borne out by the fact that but 5 per cent. of the tunneling on the east side has required timbering.

Up to the present, because of the stability and the hardness of the rock penetrated since the start of operations at the east side, much more compressed air has been required to carry on the work than has been needed at the west side. The air pressure ranges from 100 to 125 pounds to the square inch, and this air has been supplied by four compressors having a combined output equivalent to 1,650 cubic feet of free air per minute. All these machines are electrically driven, current for this and for other purposes being obtained from

Right—Transit and "sunflower" in position preparatory to mensuring the amount of rock excavated by the contractor.

Left—Using the "sunflower" in checking up the excavated area of the main tunnel. The contractor is paid in accordance with the figures obtained in this precise way.

Fig. 1—Setting up a drill carriage in one of the headings at the east portal.
Fig. 2—Air hoist equipment for lifting and shifting empty muck cars near a heading to facilitate loading.
Fig. 3—Air hoist carried at rear of air-operated shovel for shifting empty 4-yard muck cars.
Fig. 4—Section of enlarged railroad tunnel with 10-foot bench still to be removed.
Fig. 5—Manner in which R-72 rock drills are mounted on crossbars to drill holes in bench in the railroad tunnel.

the Boulder Creek station of the Colorado Power Company.

Compressed air is used in the east-side tunnels to drive drainage pumps and to assist in blowing out smoke at the headings after blasting. Air for this purpose is released from the high-pressure lines feeding to the drills; and in the course of twenty minutes the atmosphere at the headings is cleared sufficiently for the muckers to take up their work without experiencing any discomfort. The compressed air supplements the low-pressure air delivered to the headings by the 12-inch ventilating ducts.

The fine progress made at the east side is due in large measure to the character of the drills employed in driving the headings and in excavating the bench in enlarging the railroad tunnel. The type of drill used for these purposes is known as R-72, and was developed by the Ingersoll-Rand Company to meet exacting conditions such as were expected in penetrating the backbone of the Continental Divide. The R-72 is the outcome of many years of experience and much research on the part of its makers. It is high powered and exceptionally rugged; and this drifter is capable of drilling with equal efficiency holes ranging anywhere from two feet to twenty feet in depth. One of the officials at the east portal, after months of experience with the tool, thus summed up his opinion of its admirable qualities: "The R-72 is more powerful than other drills. It drills much faster, and has considerably less vibration. It is very steady on the bar; and its cost of upkeep is decidedly low."

Among our illustrations are three line drawings showing different aspects of a drill round at a typical heading in either the water or the railroad tunnel. A round consists of 24 holes arranged, as indicated, with the 8 central holes converging toward a common point and enclosing a cone-shaped wedge of rock which is blasted first by direct firing. After this wedge is shattered, the remaining outlying rock is fired successively by delay exploders, and this subsequent movement—which follows a few seconds after the cut holes have been fired—is inward upon the already broken or blasted area. A drill round is 8 feet in depth; and the resultant average advance at each blast is approximately 7½ feet. The aggregate advance at a heading in the course of 24 hours is 24 feet. In drilling each hole four bits are used—starting with a 2½-inch bit and ending with one 1⅞ inches in diameter. As a rule each bit is used but once, and is then returned to the blacksmith shop for retreating and sharpening. About 200 feet of holes is drilled at each heading. In a period of 30 days a total advance of 1,415 feet has been made by working three shifts daily.

Drill carriages have contributed considerably to the progress that has been made in driving the east-side headings. These carriages are adaptations of kindred outfits devised by the Ingersoll-Rand Company about 1912; and in their present form they were built by the Stearns-Roger Manufacturing Company, of Denver, in collaboration with the contractor and the engineers of the Ingersoll-Rand Company. The primary purpose of the drill carriage is to save time and reduce the labor ordinarily expended in setting up and in tearing down drills. Inasmuch as the equipment is mobile, the drills can be readily run up to the face and afterwards withdrawn without dismounting them when making ready for firing. The carriage also makes it practicable to move the drills far enough rearward when blowing out the drill holes to prevent the cuttings from clogging the water holes in the steels and to keep the drills, themselves, away from the flying dirt.

In its present form, the drill carriage is made up of four main parts, which are: a small 4-wheel steel truck built to run on track of 24-inch gage; a girder composed of two channel bars placed parallel, six inches apart, and bolted together; a second carriage which uses the girder as a runway; and a rig supported by this carriage and designed so that it will hold four drifters for the simultaneous attack of the rock face. The girder is mounted upon the truck by means of a pivoted connection which permits the advance end of the girder to be raised or lowered as required; and this unsupported end of the girder rests, when the drills are in action, upon a screw jack standing upon the ground. The drill-rig carriage is moved forward and back upon the girder by a windlass engaging a chain belt placed between the channel bars.

Motor-generator set, in water tunnel at Crosscut No. 5, which rectifies the current used for driving mucking machines, electric locomotives, etc.

Electrically operated mucker, at one of the east-side headings, with a 2-yard dump car in position for filling.

Timbering a weak roof in the main tunnel from a "jumbo" scaffold and using hitch instead of post.

Crosscut No. 4, showing firing box on wall at left and the ventilating door standing open.

The drill rig consists fundamentally of a 4-inch by 7-foot single-screw column which is secured horizontally to its supporting carriage by a swivel clamp. When in working position this column engages the flanking walls of a tunnel and serves to steady the drill rig against lateral movement when locked in position for drilling. This horizontal column, in turn, carries four short vertical columns, each of which has clamped to it an arm set parallel with the main horizontal column; and to each of these horizontal arms is bolted an R-72 drifter. At the rear of the drill-rig carriage there is a 2-gallon lubricator from which oil is distributed to the drills through their air-supply hose. The drills are also oiled by their individual lubricators. A manifold with four connections delivers operating air to the four drills; and a by-pass carries air to the lubricator to force oil to the drifters. The air manifold taps the main line by means of a single connection. Similarly, a water manifold is provided at the rear end of the machine so that a single connection with the water line takes care of the water needs of the rock drills.

To bring the four drills into action, the carriage is shoved forward on the narrow-gage track until the girder is close to the heading; the jack under the girder is adjusted; the water and the air connections are made at the manifolds; the drill-rig carriage is advanced by the windlass until the drill steels bear against the rock face; next, the main horizontal column is anchored against the side walls; and, with these preparations finished, the drills can be started. Conversely, to retract the outfit, the drill-rig carriage is wound rearward until its weight is over the truck, and then it is an easy matter for the crew to shove the whole equipment backward as far as desired. It is claimed that a set-up takes on an average only fifteen minutes as against an hour normally required to set up four drills on the usual mountings. Without a carriage, a driller would have to do as much work in setting up for one round as he now does for two rounds; and there is very little if any heavy lifting for him to do.

Owing to the large number of R-72's available on the east side, it is possible to subject them to frequent inspection by the drill doctor. This takes less labor and keeps the cost of repairs lower than would be the case with fewer drills in reserve. How well the drills have stood up to their task is revealed by the fact that all the necessary inspecting and cleaning have been done by one man.

Intersection of Crosscut No. 5 and water tunnel at the time the tunnel was flooded by water issuing from a porous seam tapping Lower Crater Lake. From left to right: Superintendent F. E. Stokes, Assistnat Superintendent O. A. Willson, Resident Engineer B. G. Coy, and Night Superintendent Matt Agenten.

Each shift at the headings is made up of a shift boss, four drillers, four helpers, three muckers, and two trainmen. The muckers and the drillers alternate between the headings, and the crew drills and blasts a round and clears away the muck at each heading during a shift. On an average seven pounds of 60 per cent. dynamite is required for every cubic yard of neat excavation. Something like 28 cubic yards of rock are broken up at each blast, and nearly one-third of this total is overbreak. The overbreak is due to the rather erratic manner in which the hard rock fractures. There

Drill doctor at work in an advance section of the main tunnel a mile in from the east portal.

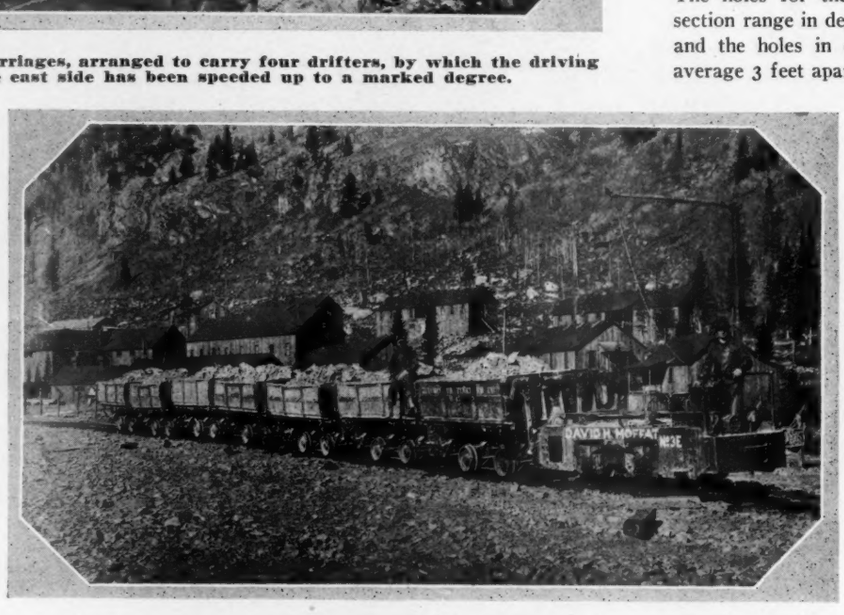
One of the drill carriages, arranged to carry four drifters, by which the driving of the headings at the east side has been speeded up to a marked degree.

are variations in the arrangement and in the number of holes drilled for each heading round—depending upon the characteristics of the rock encountered. Approximately 162 pounds of dynamite is used for a round.

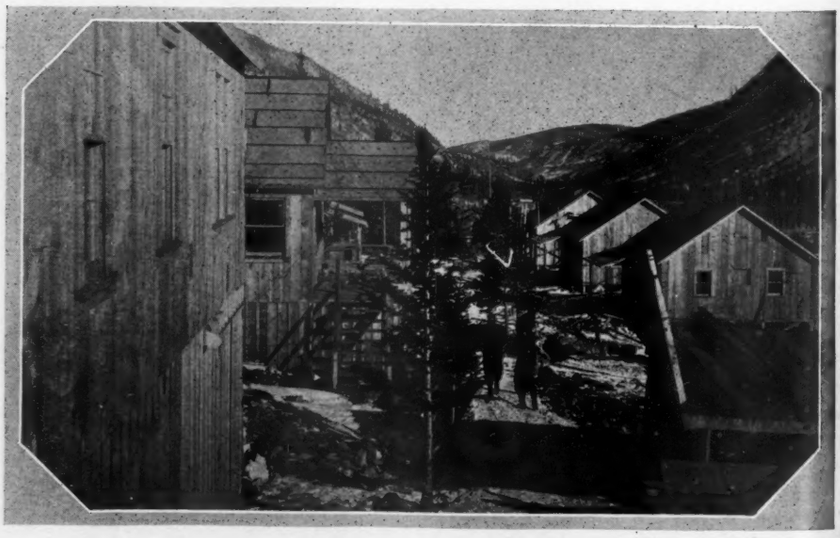
The muck is handled at the headings as already described in dealing with operations at the west portal, but this work at the east portal has been speeded up by the adoption of a simple and effective equipment used for shifting empty cars at the headings. This arrangement is composed of a piece of 3-inch pipe long enough to span the tunnel laterally and to be hung by terminal links upon two hooks driven in opposite sides of the tunnel at a suitable height. The pipe serves as a horizontal track for a trolley running on two small sheaves; and from this trolley is suspended a cylindrical air hoist, 12 inches long and 10 inches in diameter. To the lower end of the piston rod is attached a piece of rail slightly longer than the body of a 2-yard muck car; and the ends of this bar slip into eyes connected to straps which hook under the ends of a car truck. Empty cars can thus be lifted and shifted successively and with dispatch to the loading position at the rear of a mucker. It is said that the outfit obviates cutting out extra ground for a switch and that it also does away with the laying of an extra line of track for the empties. Air for operating the hoist is obtained from the line that supplies air to the drills.

A somewhat similar service is performed by a larger cylindrical air hoist secured to a swinging derrick mounted at the rear end of the Osgood air shovel which does the mucking in connection with the work of enlarging the railroad tunnel to full size. The empty 4-yard muck cars are run into position behind the shovel, and the hoist shifts the empties, one by one, to the parallel track alongside the shovel whence they can be moved forward to the loading position. This method of shifting empty cars effects a saving in time amounting to 30 per cent. over that of switching.

The enlargement of the railroad tunnel is being done by what is known as ring shooting—the holes being drilled radially from fixed points after the manner indicated by two accompanying line drawings. The thirteen upper holes are drilled by a stoper mounted upon a crossbar, while the fourteen holes in the bench are drilled by R-72 drifters similarly mounted. The holes for the enlargement of the tunnel section range in depth from 4½ feet to 10 feet; and the holes in each ring are spaced on an average 3 feet apart, while succeeding rings are spaced longitudinally 4 feet apart. It has not been found practicable to shoot the whole of a ring simultaneously, because the bench would be covered by muck. To avoid this handicap, the lower half of the ring is shot first, and then from four to six rows of the upper holes are shot—the number being determined by the space available for muck. The holes in the different rings are shot in rapid succession by means of electric delay fuses, so that each ring breaks against an open face. Ring drilling is done 200 feet ahead of the bench. An



A train of 4-yard dump cars carrying rock to the railroad fill by which the tunnel will be linked with the existing Moffat Railroad on the east side of the Continental Divide.



Section of the camp at the east portal, looking down the valley toward Newcomb on the Denver & Salt Lake Railroad.

average of three pounds of 60 per cent. dynamite is used for each cubic yard of neat excavation. The ring-shooting enlargement is advancing at the rate of twenty feet a day. The air shovel has been able to load during two shifts in one day as many as 192 four-yard cars.

The contractor is paid at a fixed rate based upon the rock removed within the "B line" of the prescribed sections of crosscuts, water tunnel, and railroad tunnel; and the exact amount of rock excavated is determined with a "sunflower". This instrument was devised some years ago for use in connection with the water-supply tunnels of New York City. It consists essentially of a graduated disk eighteen inches in diameter mounted in a vertical plane and arranged to carry a graduated rotating arm. The tip of the rod touches the rock wall at different points on a section; and the surveyors are thus enabled to obtain quickly a series of readings giving angles and distances at a number of points on the tunnel wall. These figures, when plotted, furnish the needful data from which to compute the amount of pay rock removed.

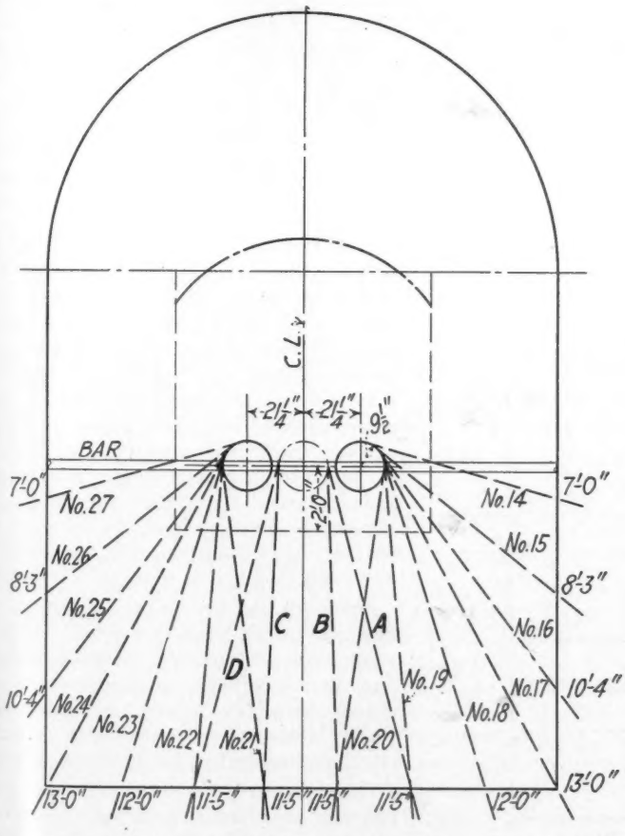
Mr. F. E. Stokes, superintendent at the east portal.

Under date of January 20, 1925, Mr. W. P. Robinson, President of the Moffat Tunnel Commission, submitted his annual report to the Commission, and we are extracting from it certain paragraphs dealing with costs. "In my July 16, 1924, report the cost of the rock excavation in the water tunnel and headings was shown to be $10.36 per cubic yard. The cost to January 7 (1925) has been $10.41 per cubic yard. This is only a slight increase in cost over the July report, and shows a large saving in cost compared with the upset price of $17. In the July report, the cost of the railroad tunnel was $4.85 per cubic yard. The cost to January 7 (1925) has been reduced to $4.80. While this is still slightly above the upset price of $4.70 per cubic yard, we have every reason to believe that this cost can be further reduced, and the contractors are confident that they can make a substantial saving under the upset price on this item.

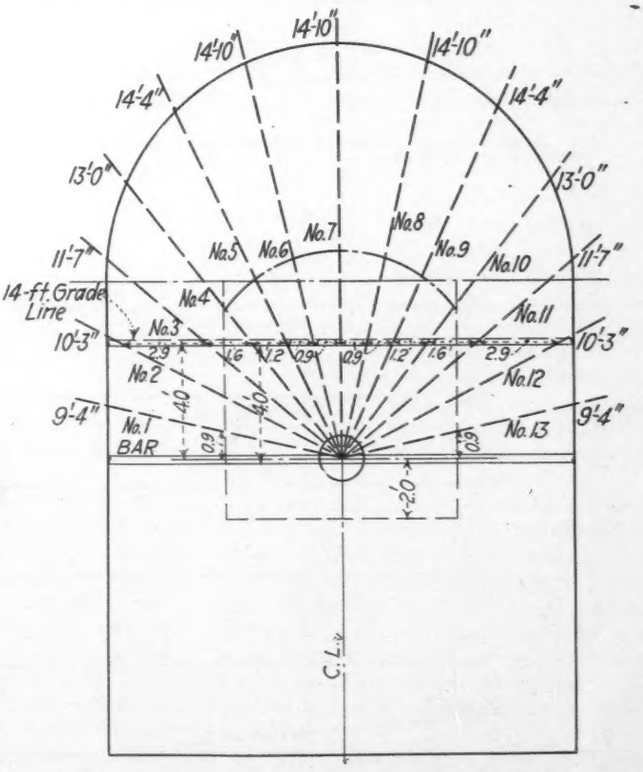
"I called attention to timbering costs in the July report, stating at that time that the estimate for timber lining had been exceeded. Then we were optimistic that the soft rock at the west portal would not continue much further, and that the savings on the other items of work would compensate for the loss on the timber items. We have over 6,000 feet now of bad ground, and no certainty as to when it will cease. The handling of this ground is a question not only of engineering but of extra costs, and the actual amount needed cannot be determined at this time."

It is pertinent at this point to recall that the original total cost of the Moffat Tunnel was fixed by the Colorado Legislature at $6,720,000 without asking for the submittal of an engineering estimate. The Legislature arrived at its figure through knowledge of the fact that some tunnels had cost more and some other tunnels had cost less to build per mile of length. However, skilful engineering and competent handling of this great task by the contractor will probably make it possible to complete the undertaking without adding to any great extent to the outlay originally prescribed.

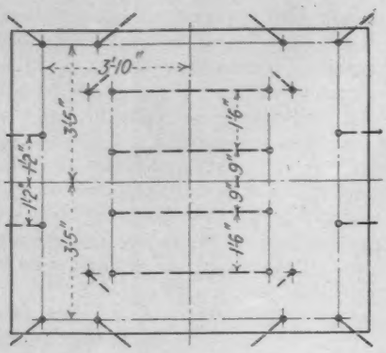
Mr. Robinson has given some instructive details which bring out forcibly the manner in which the project is being pushed toward completion. As he expresses it: "Comparisons of the rate of progress of the Moffat Tunnel with that made on other noted tunnels are interesting even though accurate comparisons are impossible where the sizes of the tunnels and the



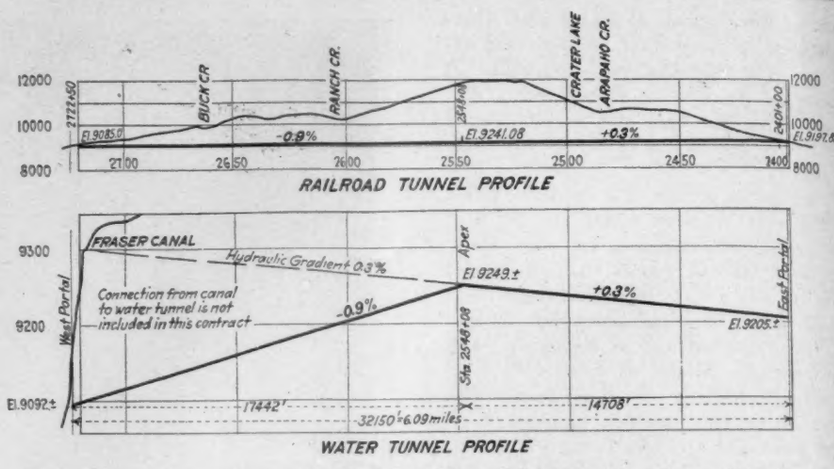
Machine set up for drilling bottom holes. When steel cannot be changed with the machine set up as shown at each side of the center line, then holes A, B, C, and D are drilled from the central position.



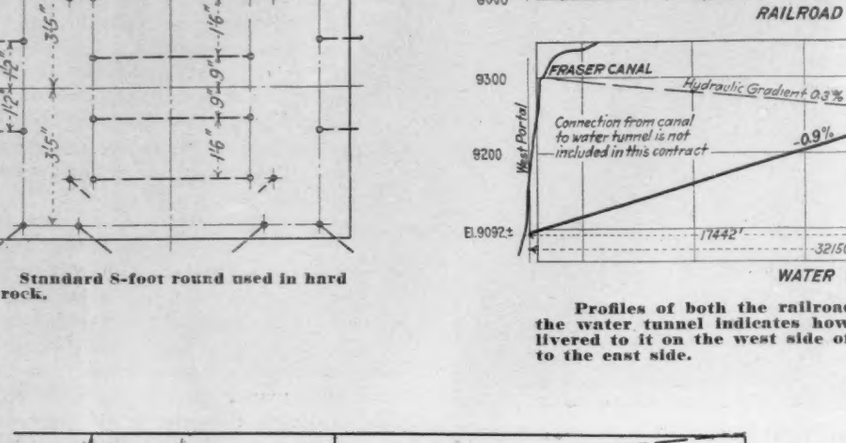
Position of stoper when set up to drill the side and the upper holes for enlarging the railroad tunnel section to full size. The small arched tunnel section indicates the size of the advance heading of the railroad tunnel.



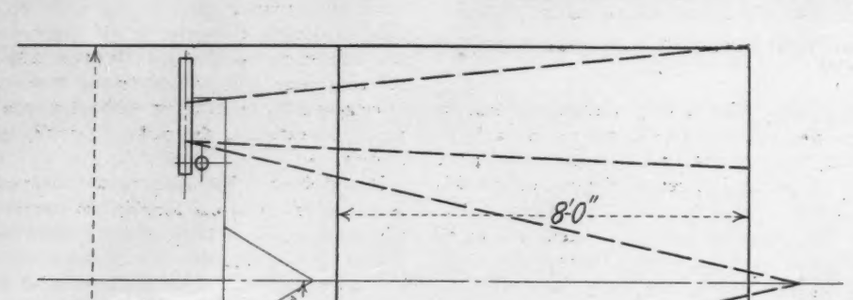
Standard 8-foot round used in hard rock.



Profiles of both the railroad and the water tunnel. The profile of the water tunnel indicates how water from Fraser Canal will be delivered to it on the west side of the Continental Divide for conveyance to the east side.



Plan view of standard 8-foot round showing position of drills with fixtures and template.



Longitudinal section of an 8-foot heading in hard rock with drill mounted on column

working conditions vary. The Rogers Pass Tunnel, on the Canadian Pacific Railroad, established a world record for rate of advance. The rock was ideal and the tunnel much larger—being 28x24 feet—which, as tunnel drivers concede, allows more rapid progress to be made than would be practicable in a smaller tunnel. The following table is suggestive:

	Average Monthly Rate	
	Rogers Pass 28x24 ft.	Moffat Tunnel 16x24 ft.
Water tunnel	609 ft.	539 ft.
Center headings ...	487 ft.	579 ft.
Railroad tunnel enlargement	655 ft.	664 ft.

At our present rate of progress we may very conservatively estimate that the tunnel will be completed in 1926, which is several months within the time originally believed possible."

SOME FACTS ABOUT DENVER

DENVER lies at the intersection of the South Platte River and Cherry Creek, twelve miles east of the mountains. According to records of the United States Weather Bureau, Denver can boast an average of 65 per cent. days of sunshine annually; has an average temperature of 72 degrees in July; an average maximum temperature of 72 degrees in January; an average yearly rainfall of 14 inches; and an average humidity of 54. The city is at an elevation of a mile above sea level, and this, in combination with its notably dry air, explains why the town is so healthful.

Denver is the first American city to have municipal parks lying in another county. It administers 17 mountain parks—aggregating more than 3,738 acres—scattered over a region of 100 square miles in the front range of the Rocky Mountains and connected with one another and the city by 75 miles of fine highways.

Denver is served by seven railroads; has an estimated manufacturing output of $65,000,000 annually; and has 1,500 retail stores. The largest industry is represented by the stockyards and packing interests, valued at $14,000,000.

Refrigeration—What and How

By CHARLES W. GIBBS

THE principles of refrigeration have been known for many years, but it is only within the last few years that the practice of these principles has been developed extensively. At the present time the refrigerating industry, or the manufacture of "cold," has become one of our greatest businesses and has a far-reaching influence on the life of each of us.

Few people realize how important is refrigeration. It is probably closest to the average person through what he eats. The family ice box is a homely example of its use, of which the immense cold-storage warehouses are but commercial enlargements. These two "refrigerators," the one at home and the other at the large distribution points, preserve the foods we eat from decay and deterioration and permit us to enjoy them both in and out of season. Fruits, vegetables, and meats are shipped by refrigerator cars over long distances, thus giving us daily many things which we could not otherwise enjoy and, in addition, broadening the markets of the growers and packers.

Refrigeration is used extensively in the manufacture of many products; in fact, there are a large number of processes which would be impossible without it. "Cold" is used in the manufacture of photographic materials, oils and greases, soaps, ice cream and candy, to some extent in the preparation of tobacco, and so on. The main branches of the industry are, however, cold storage and ice manufacture; and, as the systems used in these branches are very similar, we shall limit ourselves to the latter and then only to a brief discussion of its various features.

Refrigeration, or the artificial production of low temperatures, resolves itself into the problem of removing heat from the body to be cooled and of transferring it to some other body where it will have no undesirable influence. The home ice-cream freezer is a complete refrigerating plant. The can containing the material to be frozen is packed in ice and so rotated that the contents are stirred and all parts of the can are brought into intimate contact with the ice. The heat of the can and its contents passes to the ice, which of course melts. This merely means that the heat removed from the can becomes the "latent heat of fusion" of the ice—the transfer of this heat from the can to the ice lowering the temperature of the can. After the cream is frozen we must drain off the water which has been formed and repack the freezer with ice. To go back to the definition at the beginning of the paragraph, we must put the heat removed from the cream—now in the water—where it will have no undesirable influence. This homely example may seem a long way from modern refrigeration systems, but it illustrates the idea.

In commercial plants another physical phenomenon is used. Instead of melting or changing a solid to a liquid, and thus utilizing the latent heat of fusion, a liquid is changed to a gas—thus utilizing the latent heat of vaporization. Obviously, some liquid must be used which boils or vaporizes at temperatures slightly below those desired in the refrigerated product. There are a number of these, such as ammonia, sulphur, dioxide, carbon dioxide, and ethyl alcohol; but, because of various advantages, ammonia is almost exclusively used in commercial plants.

Ammonia boils at 0°F. when under 15 pounds gage pressure. If lower temperatures are desired the pressure may be lowered, thereby depressing the boiling point. All that is necessary to make use of this property of ammonia is to place liquid ammonia in suitable coils or other containers, surrounded by brine, air, or whatever is to be cooled, and to let it boil away—all the time maintaining a suitable constant pressure inside the coils by removing the gas as it is formed.

We now have the heat removed from the body to be cooled and in the gas. The next move is to put that heat where it will have no undesirable influence. We could throw the ammonia gas away, but the cost would be prohibitive, so we must make arrangements to change the gas back to a liquid and use it over again.

To accomplish this, two methods are used; but we will discuss only the so-called compression system. The method derives its name from the fact that a compressor is used to raise the pressure of the gas to such a point that it will liquify when cooled to temperatures easily available. In other words, we condense the gas and place it in such a condition that it can be fed again to the "boiler" previously mentioned.

It happens that ammonia gas at 185 pounds gage pressure needs to be cooled to only 96°F. in order to condense or return to the liquid

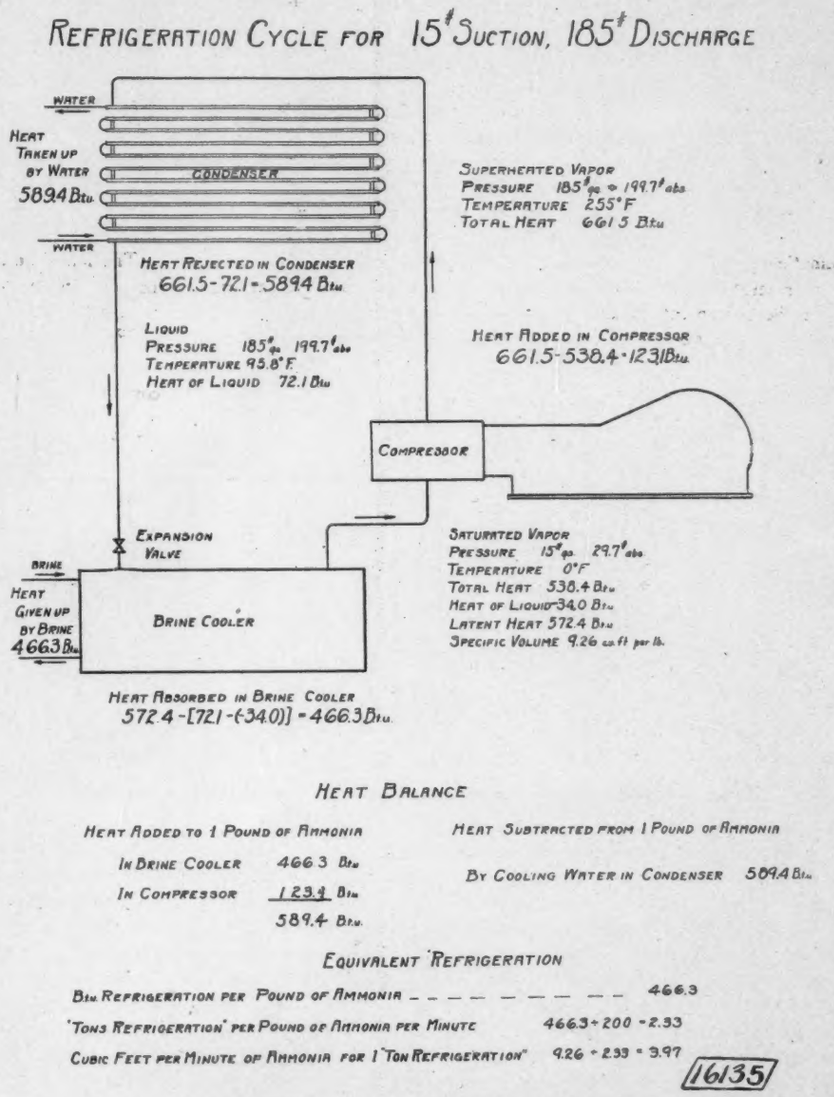

REFRIGERATION CYCLE FOR 15# SUCTION, 185# DISCHARGE
WATER
HEAT TAKEN UP BY WATER 589.4 Btu.
CONDENSER
WATER
HEAT REJECTED IN CONDENSER 661.5-72.1=589.4 Btu.
LIQUID PRESSURE 185# gage 199.7# abs. TEMPERATURE 95.8°F. HEAT OF LIQUID 72.1 Btu.
SUPERHEATED VAPOR PRESSURE 185# gage = 199.7# abs. TEMPERATURE 255°F TOTAL HEAT 661.5 Btu.
HEAT ADDED IN COMPRESSOR 661.5-538.4=123.1 Btu.
COMPRESSOR
EXPANSION VALVE
BRINE
HEAT GIVEN UP BY BRINE 466.3 Btu.
BRINE COOLER
SATURATED VAPOR PRESSURE 15# gage 29.7# abs. TEMPERATURE 0°F TOTAL HEAT 538.4 Btu. HEAT OF LIQUID 34.0 Btu. LATENT HEAT 572.4 Btu. SPECIFIC VOLUME 9.26 cu. ft. per lb.
HEAT ABSORBED IN BRINE COOLER 572.4-[72.1-(-34.0)]=466.3 Btu.
HEAT BALANCE
HEAT ADDED TO 1 POUND OF AMMONIA
IN BRINE COOLER 466.3 Btu.
IN COMPRESSOR 123.1 Btu.
589.4 Btu.
HEAT SUBTRACTED FROM 1 POUND OF AMMONIA
BY COOLING WATER IN CONDENSER 589.4 Btu.
EQUIVALENT REFRIGERATION
Btu. REFRIGERATION PER POUND OF AMMONIA ---------- 466.3
"TONS REFRIGERATION" PER POUND OF AMMONIA PER MINUTE 466.3÷200=2.33
CUBIC FEET PER MINUTE OF AMMONIA FOR 1 "TON REFRIGERATION" 9.26÷2.33=3.97
16135

Fig. 1—Refrigeration cycle and heat balance.

**The properties of ammonia as given here are not exactly as given in the latest Bureau of Standards' tables.*

form. Water must be available at or near this temperature to provide a cooling medium. Of course, hotter water may be used, but the corresponding condenser pressure will be higher also. Colder water should be used if available, because it lowers the condenser pressure and lessens the work which must be done by the compressor.

Thus, we see that in the cycle described we have removed heat from, say, brine in a large tank—thus cooling the brine and changing the liquid ammonia into a gas. We have compressed this gas and condensed it to a liquid again by transferring the latent heat of vaporization from the gas to the water. The water is usually either cooled in a cooling tower or spray pond, or it is thrown away. To return to our original definition, we have removed the heat from the body to be cooled and have transferred it to another body where it is not objectionable—in this case to the atmosphere or to the waste water.

Fig. 1 shows very diagrammatically the ammonia compression system of refrigeration and the pressure, temperature, and heat content changes in one pound of ammonia as it goes through the cycle.* It will be noticed in the heat balance that approximately 20 per cent. of the heat abstracted from the ammonia in the condenser comes from the compressor. We have not before thought of the compressor as heating the gas, but we know that in theoretical adiabatic compression the work done in raising the pressure of the gas manifests itself in the gas by an increased temperature. This heat must be removed from the gas in the condenser as well as the heat originally transferred to the ammonia from the brine.

Fig. 1 gives the heat transfer in terms of B. T. U.'s, but this is not the unit one hears when talking to refrigeration engineers. The unit employed by them is a ton of refrigeration. This is a rate of heat transfer and is equal to 200 B. T. U.'s per minute. By definition, one ton of refrigeration requires a heat removal sufficient to melt one short ton—2,000 pounds—of ice at a temperature of 32°F. to water at a temperature of 32°F. in 24 hours. Of course, this same amount of heat removed from one ton of water at 32°F. should freeze it into ice at 32°F. in 24 hours; but, on account of the losses due to radiation, etc., only about 65 per cent. of a ton, or 1,300 pounds of ice, will actually be frozen in the average ice plant for every ton of refrigeration actually produced.

So much for the theory. Let us look for a while at the way this theory is put to use in making ice for our refrigerators. We will start with the "boiler" or evaporating coils for the ammonia. These are submerged in a large, rectangular tank filled with calcium-chloride brine. Brine is, of course, used because it will not freeze at the temperatures reached and because it is cheaper than anything else which could be used. Fig. 2 shows diagrammatically this part of the system.

The evaporating coils are merely long parallel lengths of pipe so connected by 180-degree bends that a continuous pipe is formed. The liquid ammonia is fed into these coils at or near the bottom, and the ammonia gas is drawn off at the top. The flow of liquid ammonia is controlled by the expansion valve or valves. These are needle valves built for the particular purpose. They are very misleadingly named, as the liquid does not expand in passing through these valves: it is merely reduced in pressure from 185 pounds in the condenser to 15 pounds in the evaporating coils, where it remains as a liquid until boiled to a gas.

In the brine tank are placed galvanized-iron cans which usually hold about 300 pounds of water to be frozen into ice. The water may be distilled water, in which case the air system shown may be eliminated. Or it may be "raw water"—that is, not distilled, in which case the air system is necessary. As distilled water is pure and free from air it will usually make clear ice, when frozen, without the need of agitation. Raw water from wells or city mains contains various minerals and impurities and also considerable air. If frozen without constant agitation it would become white instead of clear ice, such as is demanded by the average customer. White ice is just as good ice, but we demand clear ice, therefore it must be furnished us.

Fig. 2 shows that this air system consists of an air compressor, an air aftercooler to reduce the temperature of the air, an air dehydrator to further cool the air and to remove the moisture, and an air receiver. From the receiver the air is led through headers to laterals where it is usually reduced in pressure to about 12 pounds and distributed to the cans. Each can may have a tube soldered into its side or built into it to lead the air to the bottom, or a removable tube may be hung in the center until the water is frozen. The tube can then be thawed out. The air bubbling from the bottom of the tube through the water effectively washes off the surface of the ice as it is frozen and keeps it clear of the very small air bubbles and foreign material which would make cloudy or "white ice" if allowed to remain. Low pressure air at about 5 pounds is sometimes used in what is known as the low-pressure system. Dehydrators are necessary to remove the moisture from the air before it passes through the small tubes into the cans, where it is exposed to low temperatures. The moisture would freeze and clog the tubes if it were not removed.

The liquid ammonia, before it passes through the expansion valves to the evaporating coils, is usually at about 185 pounds pressure and 96°F. temperature. This will vary with locality, season, source of water supply, etc. The ammonia gas going out of the evaporating coils will be between 15 and 20 pounds pressure and between 0°F. and 6°F. temperature, if a saturated gas. Good operators attempt to hold the gas temperature slightly higher, that is, to have a little superheat when leaving the coils. The brine temperature will be betwen 10°F. and 20°F. which, of course, is sufficiently low to freeze water.

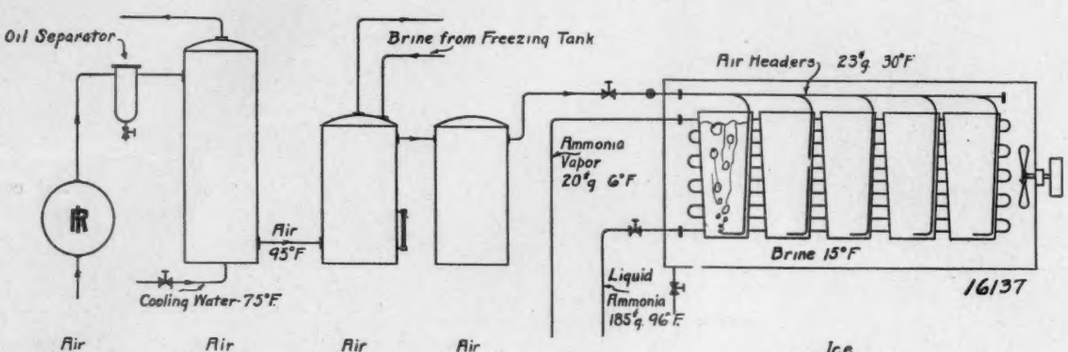
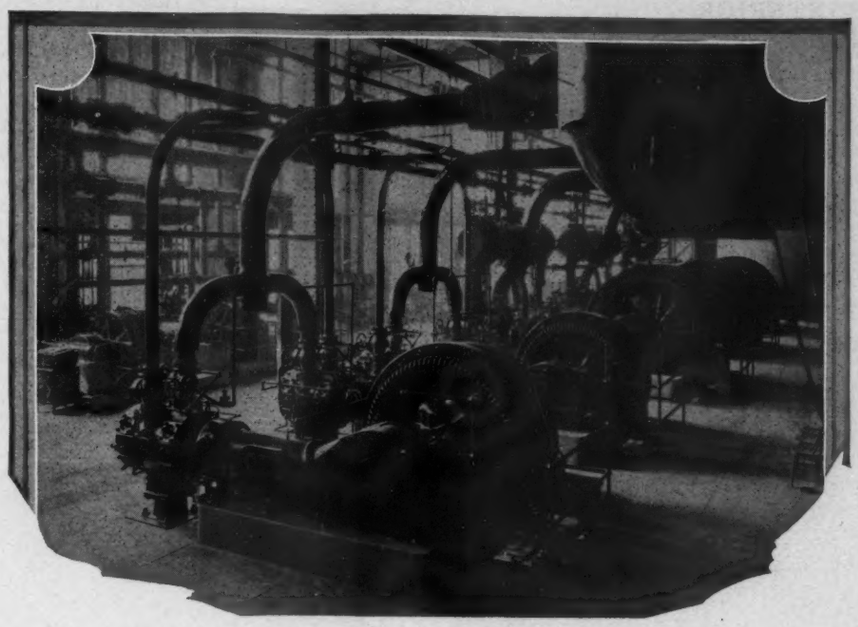


Fig. 2—Diagrammatic layout of ice-making plant and can system.

After passing out of the evaporating coils the ammonia gas usually goes into an accumulator, which is nothing more than a large receiver to catch any liquid carried over by the gas and to return it to the coils. The gas then passes to the compressor intake to be compressed to the proper pressure for condensation.

The compressor may be one of many types. It may be horizontal or vertical, single or double acting, high or low speed, single stage or compound. The majority of the very small units are vertical, single-acting, moderate-speed, single-stage units. The larger sizes have heretofore been vertical, single or double-acting, slow-speed, single-stage units; but the latest

plants are going to the horizontal, double-acting, high-speed, compound machines. These are equipped with plate valves and intercoolers to cool the gas between the stages of compression. These features make for better efficiency and economy of space and of power. The compressors may be belted or direct connected to the prime mover which may be any type of electric motor, steam engine, or oil engine. Oil-engine-driven, direct-connected units are ideal and produce refrigeration most economically. One of our illustrations shows an actual installation of the latest designs of compressors.



Air and ammonia compressors in a great plant capable of turning out 1,000 tons of manufactured ice daily.

The condenser is next in the path of the gas after it is compressed and is a very necessary and important piece of apparatus. There are many types, all of which strive to condense the ammonia gas as efficiently as possible. The operating efficiency of a condenser may be measured by the quantity of water used to cool a given amount of gas and by the closeness of the condensing temperature to the water temperature.

A very common type of condenser consists of pipe coils through which the ammonia gas flows and over which water flows—the liquid ammonia being drained off at the bottom to a receiver which stores it for distribution once more through the expansion valves to the evaporating coils. Another form is a vertical drum with tubes extending through the drum and welded into each head. The ammonia gas is inside the drum and water flows over the top edge of the tubes and through them to the bottom. This type is one of the latest and most efficient. As before, the ammonia liquid is drained off to a receiver to travel its cycle again and make more ice.

Cold storage is carried out in the same way except that the brine is cooled in a different type of container and is circulated to the various rooms or objects to be cooled. Sometimes the ammonia evaporating coils are themselves located in the cold rooms, but this is not usual.

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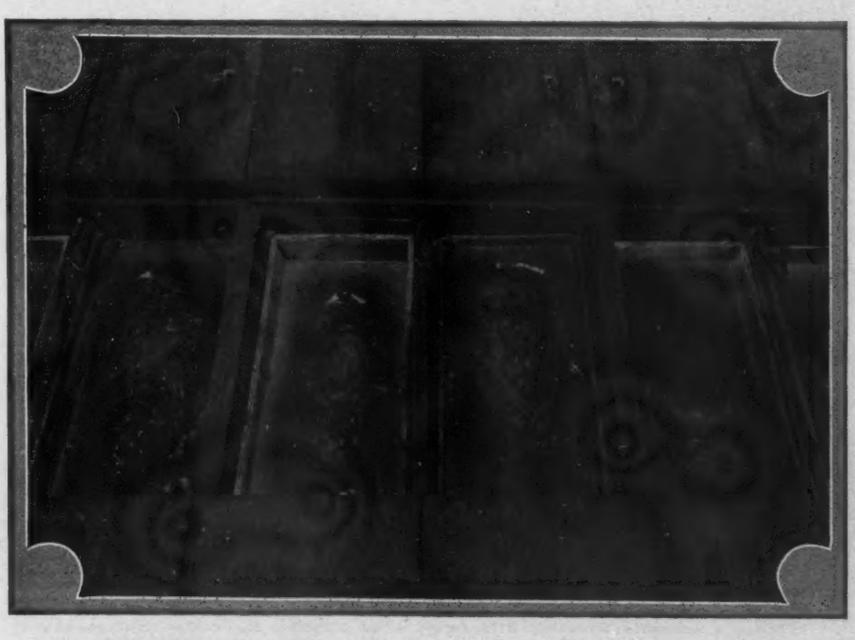
SIGNIFICANT FIELD WORK OF GEOLOGICAL SURVEY

AMONG the many interesting things done by the United States Geological Survey during the fiscal year ending June 30, 1924, the director calls special attention to certain field work in the Grand Canyon of the Colorado and in Arctic Alaska.



During freezing, the water in the ice cans is agitated by compressed air in order to produce crystal clear cakes of ice.

The Colorado Canyon expedition, which attracted some public attention, well exemplifies the success won by uniting specially trained topographic, hydraulic, and geologic engineers in a carefully planned and skilfully executed effort. This traverse of the Grand Canyon completed the instrumental surveys of the Colorado River that had been begun twelve years before at Kremmling, in northern Colorado. The mapping of 253 miles of canyons and the examination of 22 possible dam sites during the year were tasks fraught with danger, but the Government engineers regarded the danger as only "in the day's work" of scientific exploration. This thorough survey of the Colorado and its principal tributaries is the necessary preliminary to the making of Federal and State plans for the full utilization of the natural resources in a region where water gives value to land.

Equally noteworthy and equally spectacular are the exploratory expeditions into Arctic Alaska—the first made in the summer of 1923 and the second started in the following winter. This geologic examination of the naval petroleum reserve in northern Alaska has been undertaken to determine the possibility of finding oil in quantities sufficient to add materially to the reserves for the future use of the navy, if not indeed large enough to augment the nation's supply for other needs. The first season's examination along the Arctic coast of Alaska verified the reports of large seepages of oil and of geologic conditions sufficiently favorable to oil accumulation to warrant the second expedition, which started northward with dog sledges from the Yukon and crossed the Endicott Range. The area to be traversed and mapped by the three parties of this expedition is roughly 3,700 square miles, and includes the largest tract of unexplored United States territory.

SAND BLAST DOES INTERIOR DECORATING

AMERICAN business folk have their preferences when it comes to choosing a place for their noonday repast. The successful *restaurateur* realizes this and is guided accordingly. Broadly speaking, the things demanded are wholesome food, good service, and an attractive dining room. The latter essential has given rise to a convincing demonstration of the utility of compressed air as an aid to the interior decorator.

A contract for redecorating the Onondaga Hotel cafeteria, Syracuse, N. Y., was let to a local paint company that set out to do the job by hand methods. All the woodwork in the cafeteria was black-oak finished, and this finish had to be removed before a new coating could be applied. Eight men were put on this task. After a week of laborious efforts with scrapers, steel wool, sandpaper, and varnish remover, it was plainly evident that the job could not be done within a reasonable time unless attacked in some other fashion. Incidentally, the men had used about 25 gallons of varnish remover and had succeeded in cleaning only the two sides of the beams on the ceiling.

Mr. Leo J. Janks, of The Real Window Cleaning Company, was then called upon to finish the work. The Real Window Cleaning Company had previously extended the scope of its activities to cleaning the entire exteriors of buildings and was, therefore, acquainted with the advantages of sand blasting. It had learned to do work of that nature at the lowest cost and in the least possible time.

Five men, an Ingersoll-Rand 5x5-inch Type Twenty portable air compressor, and sand-blast equipment were assigned to the work; and in just two weeks' time all the woodwork, representing about 18,000 square feet of surface, was cleaned. The process used under Mr. Janks' direction left the wood with its natural-oak finish. This was so pleasing to the hotel management that it was decided to leave the woodwork as sand blasted and use only a very light coat of filler.

Another task to which this enterprising concern has recently devoted its facilities is rather novel. After cleaning, by sand blast, the exterior of the Liberty Bank Building, at Syracuse, it was desired to apply a water-proofing compound to the facade. This was done with compressed air in much the same manner as paint is sprayed.

After cleaning the handsome facade of this bank building, air from the same portable compressor was used to spray on a waterproofing fluid.

AIR POWER IN THE PERFUME FLASK

IF Milady applies perfume with a hand sprayer, she uses the power of compressed air on a small scale. If her choice is a delicate scent, the same power may have been used in its making. Let us explain: The natural scents of the most delicate flowers are captured, in France, by laying fresh flower petals upon wooden frames each holding a plate of glass about 24x36 inches. This glass is coated with a non-odorous grease, generally pure white lard or refined beef suet, and the flower petals are spread lightly on it by women. Several frames are placed one above another, so the odor is caught between two layers of grease.

After a day, the flowers have either given up most of their odors or they have started fermenting, so they are replaced with fresh flowers. This is done again and again, until the fat will take up no more odor. Then the grease or *pomade,* as it is called, is gathered into receptacles for the perfumer, who recaptures the odor by churning the *pomade* in alcohol.

Formerly, the spent flower petals were picked off singly by women, which not only proved slow and costly but often left in the grease parts of exhausted petals, which fermented and lowered the quality of the pomade. Manufacturers at Grasse tried placing netting, gauze, and other fabrics between the petals and the grease to facilitate removal, but with poor results.

Finally, a few years ago, a combination machine for doing the work was invented by Lautier Fils, and this is now in use. The *chassis* or frames are passed between rapidly revolving brushes that quickly flick off most of the flowers, without touching the grease coating. This leaves small fragments of petals and stems, however, and these are removed by a suction or vacuum apparatus. In this way the work is done six times as fast as by hand, and the surface of the grease on the frames is left clean and smooth.

ANCIENT AMERICANS MADE WONDERFUL MOSAICS

IN repairing the walls of the prehistoric ruin of Casa Grande, Arizona, Government workers uncovered a cache containing mosaic work unlike anything heretofore discovered in the Southwest. The mosaics reveal that the artisanship of the people that once dwelt in this region was equal to that of other Southwestern culture; and in workmanship and in beauty of design the mosaics closely resemble those of modern times.

Three pieces were found: two of them in the form of birds and the third representing a turtle. The larger of the birds, which is the best preserved, is made of 492 stones each worked out in pyramidal shape and placed in wax on a wooden core. This mosaic measures about 4½ inches from wing tip to wing tip and has a large piece of red shell in the center as a contrasting motif. The turtle is composed of 1,129 stones. With the mosaics were found a set of perfectly matched turquoise pendants and more than 900 shell beads.

Interior decorators have recently found sand blasting the easiest and most effective way to get rid of old varnish in refinishing ornamental woodwork. Dark areas show where the discolored varnish has not yet been removed.

North Africa Important Source of Phosphate Rock

An Arid Region That is Producing Large Quantities of Plant Food for the Fields of Europe

By A. GRENON and A. S. TAYLOR

THOUSANDS of years ago, when the Atlas Mountains were thrust skyward by a seismic disturbance, the northern coast of Africa was raised from the seabed and marine life of many sorts was exposed to the light of day to undergo various kinds of transformation—much of it becoming fossilized in the course of time. Thus was brought into being the vast deposits of phosphate rock which extend over wide areas in Algeria, Morocco, and Tunis.

The phosphate deposits in Algeria and Tunis have been exploited for years, but those in Morocco have been worked only recently, and some of the operations there have been largely of an exploratory character. The Morocco activities are controlled by the *Office Cherifien des Phosphates*. It is confidently expected that the output of the Moroccan mines will in the near future equal that of the workings in Algeria and Tunis, and will, therefore, contribute substantially to the needs of agriculture. Phosphate, as is well known, is indispensable as a fertilizer and is used extensively in the same way that nitrates and potash are employed to enrich the soil.

The phosphate beds of North Africa were discovered as recently as 1885 by Philippe Thomas, a geologist, and then appeared as outcroppings on the slopes of the mountains adjacent to the road from Gafsa to Tarmeza in the southwestern part of Tunis. The importance of this source of phosphate rock can be realized when we recall that the mines in North Africa can yield thousands of millions of tons of this essential plant food. It might also be pointed out that this phosphate rock is competing with that found in Tennessee and Florida, and which has been marketed since 1897. The whole of Europe needs this mineral to stimulate the fertility of its fields.

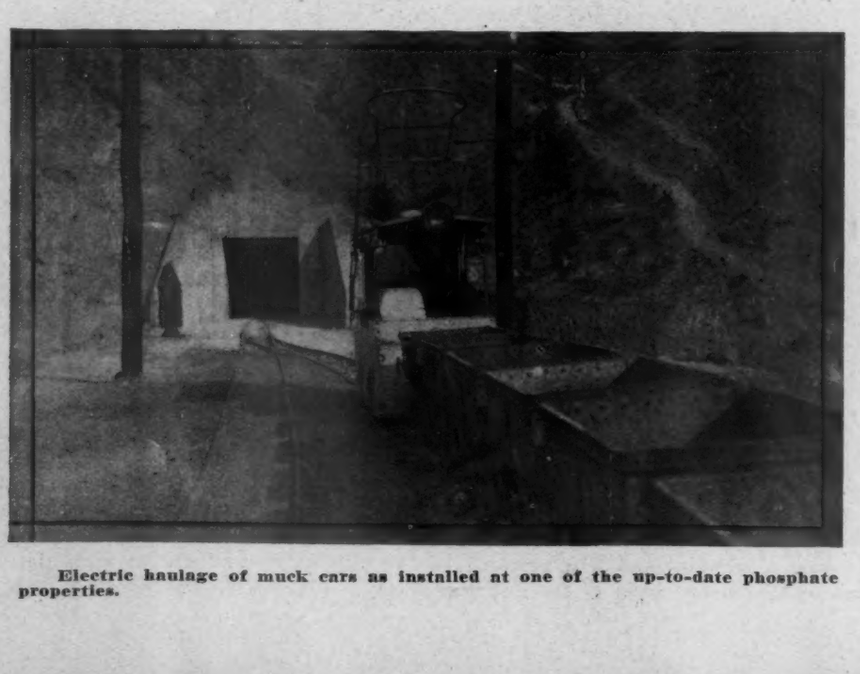
Left—"Leyner" sharpener and "Leyner" oil-fired furnace in blacksmith shop on one of the Constantine properties.
Right—Using an X-70 drill in open-cut work at Djebel-Kouif.
Bottom—Drilling into phosphate rock with a "Jackhamer" fitted with a twisted steel.

How the phosphate rock was formerly trammed from the mines to the outside dumps.

In 1886, the world production of phosphate rock amounted to only 850,000 tons, and by 1900 this had increased to 2,500,000 tons. In 1914, production reached 7,000,000 tons, and 2,500,000 tons of this was obtained from the deposits in North Africa. During that year America shipped to Europe a total of 1,600,000 tons of the commodity. The rock mined in Morocco, Algeria, and Tunis is described as a tricalcic phosphate. It generally contains from 58 to 63 per cent. of phosphate, with an amount of iron and alumina of less than 2 per cent., and something less than 4 per cent. of carbonate of calcium. After the raw rock is broken and dried in a rotary furnace, or spread and exposed to the sun if the season permits, it is delivered to chemical works for treatment with sulphuric acid. The reaction yields a superphosphate carrying as high as 12 to 15 per cent. of soluble phosphoric acid —a form in which the plant food is readily assimilated by vegetation. It seems strange, no doubt, that the mineral so essential to abundant crops should be obtained in a section of the world substantially devoid of vegetation.

The mines are located at points inland from the coast anywhere from 100 to 150 miles, and this has necessitated the construction of railways over desert regions and into mountainous districts to altitudes varying from 1,000 to 4,000 feet above the sea. These railroads run to and from the harbors of Bona, Tunis, Susa, and Sfax. The northern coast of Africa was once dotted with ancient centers of civilization, and numerous evidences of this fact remain to bear mute witness to the glories of the past. Algeria and Tunis, centuries before the Christian era, were under the sway of Carthage and, later, were dominated by Rome. Vestiges of their wealth survive in the ruins of Timgad; in those of Tebessa, with its curious walls and elegant porches; in those of Feriana; and in those of Thala and of El-Djem where there is in a desert, so to speak, a comparatively intact circus which is of a size ample enough to have accommodated 25,000 spectators in the days gone.

Moving a train load of phosphate rock from mines at Gafsa to the seaport at Sfax.



Electric haulage of muck cars as installed at one of the up-to-date phosphate properties.

Phosphate mining, except where the rock at widely scattered points rises to the surface, is carried on underground; and the beds are worked at depths ranging from 50 to 2,000 feet. The beds are anywhere from 4 to 12 feet thick; and the mineral is brought to the surface up ramps or by way of shafts, depending upon circumstances. Where the rock outcrops the open-cut method of mining is employed. The mining properties are first explored by boring down from the surface with Calix core drills. Some of the companies are equipped with several of these drills; and by means of them it is possible to ascertain the positions of the beds, their vertical thickness, their depth underground, and the constituents of the phosphate-bearing rock.

The phosphate rock is not very hard; and its color ranges from dark to light gray according to the amount of water carried. How-

ever, the deposits are covered with a harder limestone and with interposed strata of marl and sometimes of gypsum. Occasionally the phosphate rock contains nodules of flint and numerous fossils—among these being the petrified teeth of sharks. The odor of the phosphate rock when newly mined is often noisome, and not infrequently it emits a smell not unlike that of gasoline. The miners have been drawn principally from native sources with a sprinkling of Europeans. Before the war plenty of native workers were available at a daily wage varying from 30 to 50 cents. This is no longer the case; and now the majority of the miners are recruited in Morocco, Tunis, Tripoli, etc. While the average rate of pay does not yet exceed half a dollar, still this is fairly high owing to the laziness of the natives and to the small output per man.

The indolence of these people contrasts sharply with the alertness of workers in other parts of the world. For instance, at one of the most important of the phosphate mines, the native laborers form small groups that use successively the same number or time check.

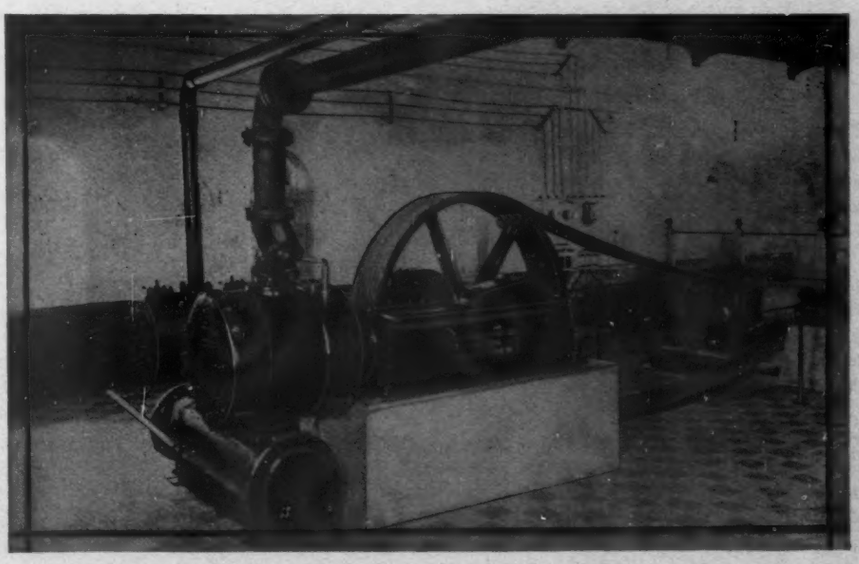
This is not a fossilized raven but a bit of phosphate rock containing the petrified tooth of a prehistoric shark.

Docks at Bona equipped with up-to-date facilities for the rapid loading of phosphate rock aboard outward-bound steamers.

In Tunis, the principal mines are those of the *Compagnie du Chemin de Fer et Phosphates de Gafsa,* where 8,000 miners are employed. This company produces annually about 1,500,000 tons of phosphate rock. At their mines at Metlaoui the rock contains from 58 to 63 per cent. of phosphate, while at Redeyef the phosphate content of the rock varies from 63 to 68 per cent. A new mine is being opened up by the company at Ain-Moulares. The concessions of this big concern extend over a stretch of territory having a length of 45 miles; and it has installed at different points a number of Ingersoll-Rand compressors requiring 1,000 H.P. to drive them.

Next in importance comes the *Société des Phosphates Tunisiens,* which has an output of 400,000 tons a year. The company is opening new workings at Meheri-Zebbens and equipping them in the most modern manner.

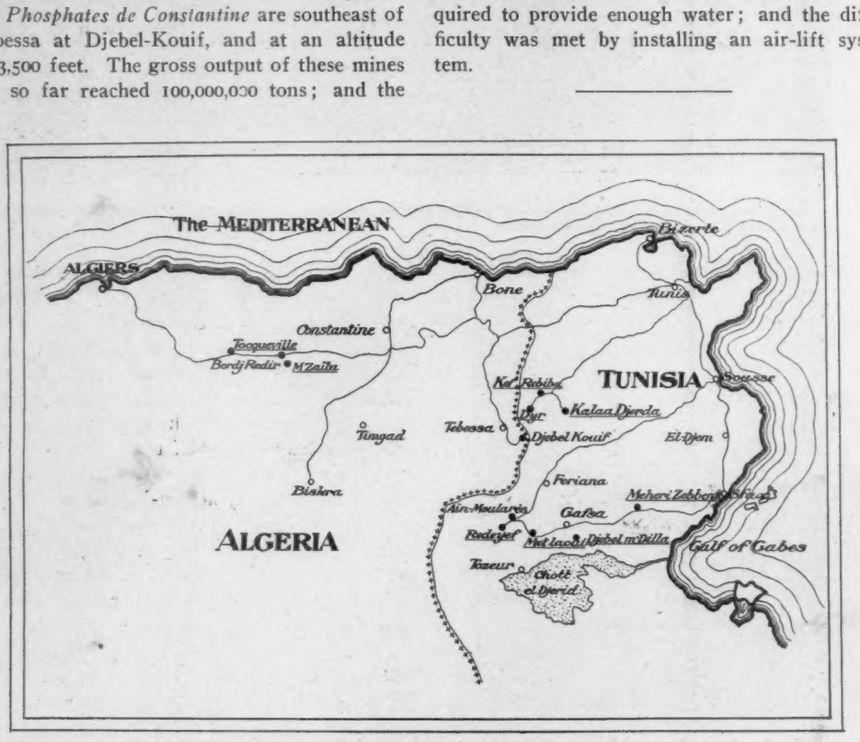
Each day, one of the members of this association goes to work while the others stay away and just bask in the sunshine. Naturally, the individual share in the day's wage is reduced to the trifling sum of from 10 to 20 cents, depending upon the number forming this curious partnership. To offset this lazy spirit and to hold the otherwise floating workers the companies have instituted a premium system, and they make a practice of increasing the wages of men that have been on the payroll steadily for one, two, three years, etc. The frugality of the natives is noteworthy. For example, in certain of the mines ten years ago some of the *Kabyles* would work for six months or a year —earning in that time a sum equivalent to $70 or $100. With this money in hand they would then drop their jobs and live without further effort for a period of three or four years. Owing to this state of the labor market, the mining companies have latterly abandoned hand methods and have substituted air-driven tools and other pneumatic equipment for different purposes.



An electrically driven air compressor in one of the central stations of the Societe des Phosphates Tunisien.

The expectation is that it will be possible thus to produce 650,000 tons during the current year. The central stations of the *Société des Phosphates Tunisien* have a total of 3,000 H.P. installed for the purposes of mining, hauling, and drying the phosphate rock; and its Ingersoll-Rand electric-driven compressors supply air for operating its drills of the same manufacture. The *Société des Phosphates du Dyr* and the *Société de Rebiba* produce, together, about 150,000 tons yearly.

In Algeria are the *Compagnie Centrale des Phosphates*, the phosphate companies at Tocqueville, at M'Zaita, and, last, but most important, the *Compagnie des Phosphates de Constantine*. The mines of the *Compagnie des Phosphates de Constantine* are southeast of Tebessa at Djebel-Kouif, and at an altitude of 3,500 feet. The gross output of these mines has so far reached 100,000,000 tons; and the annual production averages 800,000 tons. The phosphate content of the rock runs from 65 to 70 per cent.



Part of North Africa which is rich in deposits of phosphate rock.

The seaport for the Constantine properties is Bona, or Bône as the French spell it, and is linked with the mines by a railroad 150 miles long. The harbor facilities developed by the *Compagnie des Phosphates de Constantine* are fairly extensive and modern—including, as they do, automatic loading apparatus which make it possible to load vessels at the rate of 10,000 tons every 24 hours. At Djebel-Kouif there is a central station in which Diesel engines are placed which drive generators producing 1,500 H.P. of electric energy. Half of this power is used to operate compressors.

The Ingersoll-Rand compressors are equally divided between the central stations at El-Bey and at Djebel-Kouif, and the air from them is employed to drive cutters and "Jackhamers." The cutters are used for advance work at the headings in big level galleries and in transverse galleries, and for exploratory operations in mines where the underground workings extend for several miles. The big pillars of ore standing between adjacent galleries or drifts are successively removed in sections. The amount of explosive, *cheddite*, used varies between 0.2 and 0.22 pound per ton of rock blasted.

At these up-to-date mines compressed air is also employed to operate hoists, doing hauling on the ramps or slopes, and to work air lifts raising water from a depth of 750 feet. Surface water is a rarity on the uplands of the Tebessa district; and at first all the water to be had was carried from springs situated from three to six miles away. It then became plain that some other means would be required to provide enough water; and the difficulty was met by installing an air-lift system.

VANADIUM—A CURIOSITY AMONG MINERALS

WE are indebted to *Research Narratives* for the following entertaining description of vanadium which has proved of conspicuous value in working certain metallurgical wonders. This silver-white metal derived its name from *Vanadis*, a Norse goddess. But the tales of mythology are no more romantic than the story of the search for vanadium, when once its possibilities for usefulness were grasped.

This chemical element was discovered in 1801 by Del Rio, a mineralogist in Mexico; but it remained practically in oblivion for a century thereafter except in the form of museum specimens. It was not until 1900 that Professor Arnold, connected with the University of Sheffield, England, conceived the idea that this strange metal might impart some beneficial properties to tool steel. At that time, vanadium was considered a rare element and cost much more than gold.

Two brothers, J. J. and J. M. Flannery of Pittsburgh, having heard of this strange metal element and its stranger influences on steel, conceived the idea of obtaining financial aid from some business friends in order that the substance might be made commercially available to steelmakers in that center of the American steel industry. After hunting the world over, they finally succeeded in locating a rich and unusual deposit of vanadium sulphide in the Peruvian Andes at a point 16,000 feet above the sea. The next job was to convince American steelmakers that vanadium could be used by them to advantage.

Without going into details, many of them of great interest, it is enough to mention here that vanadium is now an essential component in the composition of high-speed tool steel, which fashions our machines of peace as well as our instruments of war—helping to form our monster guns and to construct our automobile engines. Also, vanadium gives to steels used for various structural purposes valuable and enduring properties which they might otherwise not possess. Vanadium imparts to tool steel the capacity to cut other metals at so high a speed that the tool actually becomes red hot and yet retains its cutting edge.

In the early days of vanadium's commercial application it was conveyed to the coast from the heights of the Andes on the backs of nimble and sure-footed llamas; but as the demand for the mineral increased its transportation was turned over to specially constructed narrow-gage railways and to motor trucks which, today, carry it from regions of perpetual snow down to the Pacific ports whence it is distributed the world over.

ENGLAND BUILDING MONSTER PASSENGER DIRIGIBLES

THE British Government has definitely decided to carry on a dirigible air service on an experimental basis for a period of three years. Two airships, known to be about twice the size of the American *Los Angeles* type, are under construction in England, and it is estimated that each will have a capacity for 100 passengers, with baggage, and will make the flight from England to India in 100 flying hours with one intermediate stop.

According to present plans, the first base is to be located at Karachi. Although Bombay is a better commercial aviation center than any other in India from a business standpoint, climatic and geographic disadvantages place it out of consideration. Some thought is being given to a dirigible service between London and New York. If this is undertaken, it will be possible to make the trip from New York to Karachi in one week's flying time.

The two dirigibles should be ready by the end of 1926 so that the England-to-India service can be inaugurated early in 1927. A figure of £100 has been set as the probable fare for this voyage.

There are 175 sugar mills in operation in Cuba, and it is estimated that the 1925 output will approach the 2,000,000-ton mark.

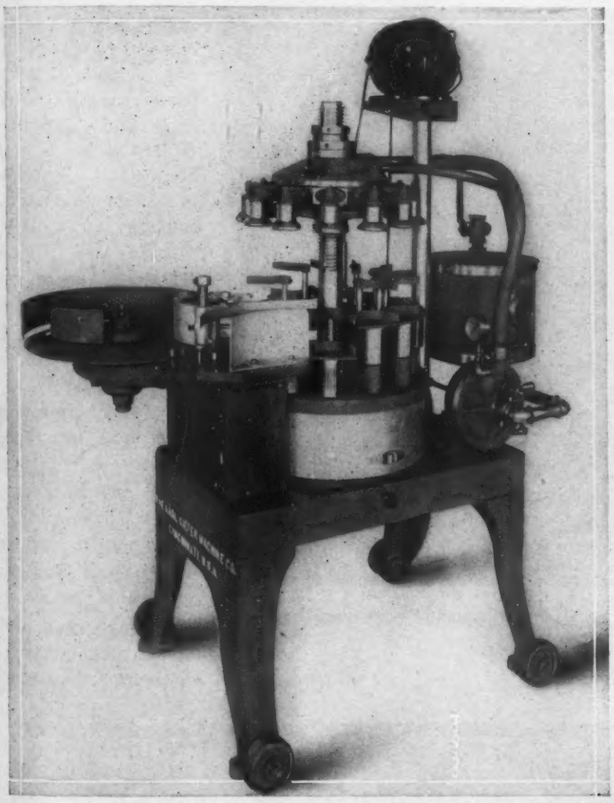
The Air Giant On The Dinner Table

Compressed Air's Part in the Packing and in the Preparation of Foodstuffs

By JAMES H. COLLINS

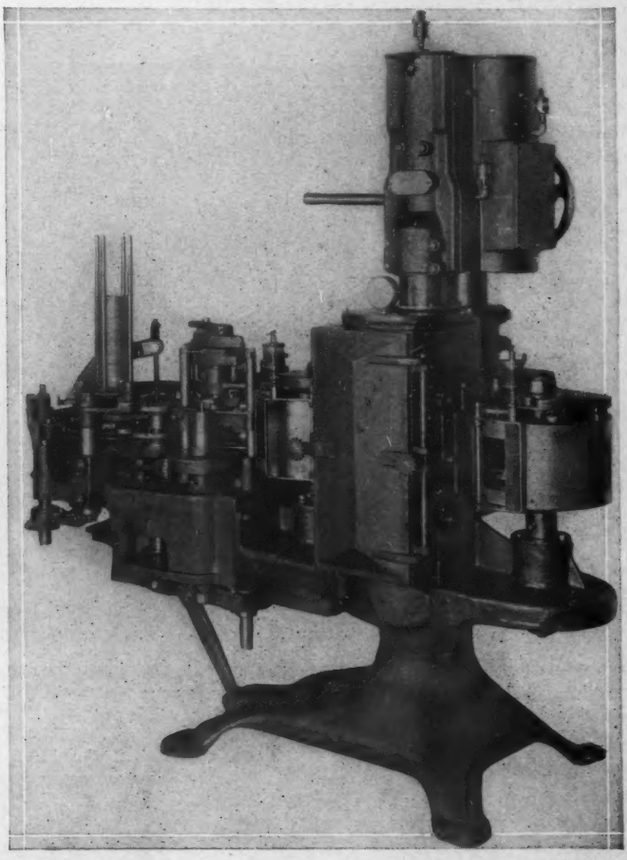
S-s-s-s—! Did that tin can hiss when you punctured the top—or bubbles s-s-s-p in the glass jar as you finally got the trick lid off?

Then some sort of air compressor was used in putting up the food, whether it be canned tomatoes, ripe olives, mayonnaise, chili sauce, or maraschino cherries. Most likely an air compressor in reverse, however, for while the power of air is used widely nowadays in the packing and preservation of food products it is used oftenest as suction or vacuum. The air giant is set, again and again, the task of holding a besieged door. The door is the hermetically sealed tin, bottle, or jar, and the air giant is guarding the food inside against the never-ceasing onslaughts of bacteria that would destroy it.



Courtesy Canning Age.

Pneumatic machine devised for filling catsup bottles.



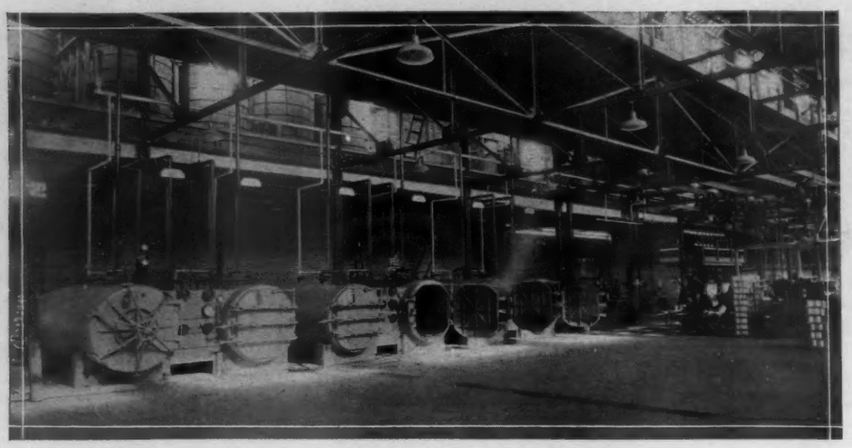
Vacuum machine which fills and caps foodstuff containers.

Man began using air power in his food not simply years, but centuries ago. Only he didn't have machines. Mechanical compression is a thing of about three minutes ago, figuring man's life back 500,000 to 2,000,000 years. Having practically no machines until a few decades ago, man used yeasts, enzymes, and bacteria. The Amalgamated Union of Swiss Cheese Hole Makers! One of the oldest labor organizations in the world, composed entirely of skilled workers in compressed air and closely allied with the labor union that puts holes in bread and still another that inserts the bubbles in champagne.

Fresh Swiss cheese has no holes. It may be cured entirely without holes and still be good Swiss cheese. Doubtless, man made cheese long before he planted crops, having discovered that this was a good way of storing the milk of his herds of sheep, goats, camels, asses, horses, or whatever animals were domesticated before the cow. In the making of Swiss and other cheeses, bacteria are incorporated in the curd at some stage of the process. In curing, they grow and produce the holes in Swiss cheese, the green spots in Roquefort, the rich haunting bouquet of Limburger. By regulating the temperature in curing Swiss cheese, these bacterial air compressors make the holes large or small, as desired, taking anywhere from three to ten months for the job. In the same general way, bacterial air compressors make the holes in bread, and put "zip" in sparkling wines. One of the first things man learned about food preservation was that these air compressor germs would, in certain cases, transform perishable foods to make them keep. It is conjectured that he found grapes growing in places like ancient Greece, where the autumns were hot and dry; that he learned to squeeze the juice out of the grapes for a cooling drink; and that he discovered that some of this left-over juice, when allowed to ferment, automatically preserved itself with a thrilling "kick."

Modern science has devised other ways of blowing bubbles in food: by mixing a powdered acid with a powdered alkali, for instance, and by putting them into biscuit dough. When moistened, these chemicals react on each other and generate compressed air more quickly than yeast does, and so we have the handy baking-powder tin and the holes in dumplings.

You will hardly be in London 24 hours without taking tea in an A B C shop, named after English aerated bread. This bread is made by charging the dough with carbon-dioxide gas, much as lemon pop is charged, to make holes in the bread when baked. Such bread can be made more quickly and cheaply



Courtesy Canning Age.
Battery of steam retorts in which cans of tomato puree are cooked.

than yeast bread, and is believed by our English cousins to be chemically purer. To Yankee taste, however, it seems a bit flat.

In that "s-s-s-s-s" the tin can is trying to tell a long story about air power on the dinner table. "Once upon a time," it says, "there was a Frenchman named Appert, who found that perishable food could be heated and sealed up in glass jars and kept indefinitely — sometimes. He did it by boiling the food; but this gave only 212°F. of heat, and some foods needed higher temperatures. Therefore Père Appert's preserved foods frequently spoiled, and were thrown back on his hands by indignant purchasers. Later in the 'forties,' another member of his family, Raymond Chevallier-Appert, took two crude pieces of apparatus and devised steam cooking under pressure, which produced higher temperatures. One contraption was the autoclave, a closed boiler. It gave higher temperatures than could be obtained by boiling, but it was just as apt to give too much heat. The other contrivance was a manometer, a steam-boiler gage. He used the manometer to regulate the autoclave, and thus originated the modern steam processing or cooking appartus for canned foods."

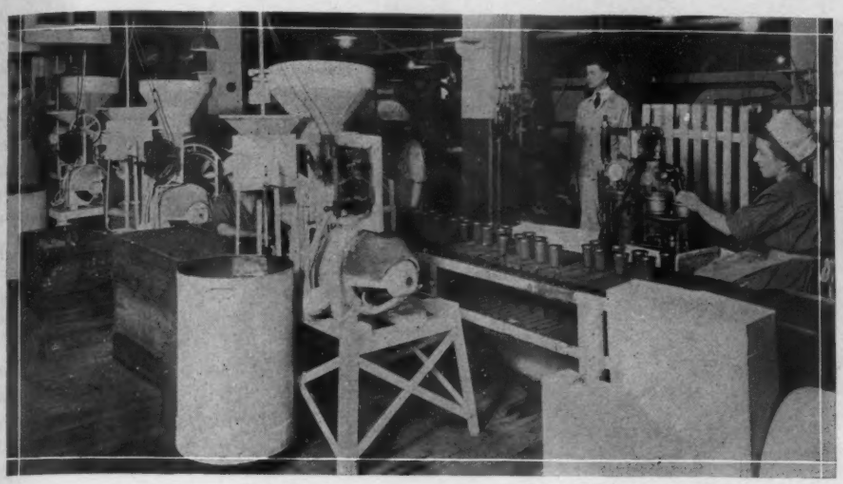
Today, the closed retort with steam under pressure is used in processing or cooking many foods packed both in tin and glass. In other cases, the cooking is done in continuous retorts, open at each end, through which the containers pass slowly so many minutes. But the air giant is invariably there holding the vacuum door. Containers are filled with cold fruits, vegetables, meats, or whatever is to be conserved. Then they are given a preliminary heating without the top. This expands the food, making the container brim full. Then the top is sealed on; the final cooking is done; and, when the container cools, a vacuum is left, with the air giant on guard. In the case of many foodstuffs packed in glass—articles cooked before being put into the container, like catsup, or not cooked at all, like pickles—a vacuum is created by the machine that puts the top on. The vacuum augments the keeping qualities.

Air compression in reserve—vacuum—is absolutely indispensable to the canner in putting up things like evaporated milk and condensed soups, for these products are cooked in vacuum pans before going into the tins. The American genius Gail Borden conquered one problem that baffled old Père Appert, that of canning milk. Back in the "fifties" Mr. Borden took fresh milk of high cleanliness, and condensed it in a vacuum pan that belonged to Shaker folk in New Lebanon, N. Y., a piece of apparatus not much bigger than a tub but quite a wonder in its day. Today, vacuum pans used for condensing and evaporating milk are as big as a house, and are lined up in regular batteries for cooking soup and other foods for cannings. Around a cannery you'll generally find some form of compressed air used for preparing the things that go into cans.

Air-operated bottle-blowing machines which perform their several tasks with astonishing speed and precision.

Down in Georgia they have built up quite an industry in the canning of the sweet red peppers known as pimentos. We used to import them from Spain and Italy, where there is plenty of cheap labor for peeling and seeding the peppers. In Georgia the peeling is

Part of a plant where pressed-glass tableware is made.



Air is sucked out of the glasses while they are being filled with peanut butter.

done by roasting the pimentos and by brushing off the blistered skins—the seeds being removed by suction. In canning peas it is necessary to sort out those that are split or light. That is done by passing them through water gently agitated by compressed air, which floats off the culls. It takes lots of hand labor to pick the claw meat out of crabs and lobsters: it is far better and cheaper to blow it out with compressed air. The canner has to do a great deal of washing—such, for instance, as getting all the sand out of spinach. Soaking and spraying do some of this work, but frequently a spray gives better results if it is reinforced with compressed air. Both pressure and suction are used in many of the machines that fill food containers, that put mayonnaise and mustard into bottles. Compressed air is also utilized in testing tin cans after they have been made. Before the top goes on they are clamped by an automatic device, subjected to air pressure, and every defective can is thrown out by the machine. And to prevent some of the glass jars breaking in the cooking retort, through the expansion of their contents by heat, they are processed under equalizing air pressure.

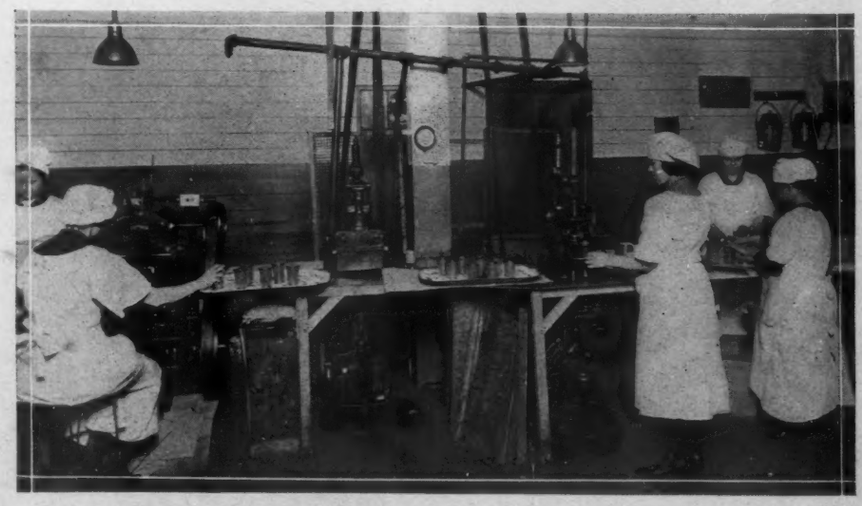
Have you ever cracked an English walnut and found the meat blackened? That means a nut which has passed through at least one summer—the blackening is oxidization caused by heat. In California, walnut growers found that by putting the meats in a tin can, and exhausting the air, the nuts would keep through any summer. This vacuum idea is now being applied to many foodstuffs. Perhaps you get your coffee in an exhausted can—the removal of even the slight amount of air in a pound of coffee preventing loss of flavor and of aroma by oxidization.

Another form of vacuum machine used in capping and sealing glass food containers.

You can live as far East as Chicago, nowadays, and have for dessert fresh red raspberries grown on the Pacific coast. Air power! The red raspberry is about as delicate a fruit as grows. It can be shipped some distance in an ordinary refrigerator car, maybe from 500 to 1,000 miles. But by precooling it will go 2,000 miles and turn up at the table as fresh as though it had been picked in the home garden. To precool them, the berries are put into a refrigerator car, the doors are sealed, and an enormous mechanical refrigerating elephant wraps his canvas proboscis around a trap door in the car roof. He breathes compressed cold air, this elephant; and, giving several loud sighs, draws warm air out of the car and lets in cold until the fruit is robbed of its vegetable heat. This retards spoilage, for even a flower will keep longer after cutting if it is cooled down. Incidentally, if there are any moths or other insects in the carload of fruit they are all drawn out with the warm air.

Will you have some of this halibut with the egg sauce? The outside of that roast beef looks crisp and fine! Please pass the butter. Isn't the air giant wonderful! Halibut is a seasonal fish. They can't catch it all year round, so some of the surplus is put away in cold storage. Eggs are put in cold storage, and so are beef and butter.

By the compression system of artificial re-



Photos, Courtesy Canning Age.

Vacuum capping and sealing machines.

Fish put up in this way will keep indefinitely because of the parts played by compressed air and vacuum in their preparation and packing.

frigeration and ice making, which is most commonly used, ammonia gas is reduced to a liquid by pressure and chilling and then conducted through expansion pipes that permit it again to become gas. In doing so it absorbs heat and effects refrigeration that makes possible the wide range of cold-storage foods on the American dinner table. Mr. Average American is now so accustomed to them that, in many cases, he does not know the difference between fresh and cold-storage foods, and has to take a trip abroad to realize how excellent the latter are.

For example, that roast beef. In Buenos Aires, shiploads of refrigerated beef are sent to Europe; but the Yankee visitor will find only fresh-killed beef in the market, for the Argentinos are accustomed to fresh-killed meats and will have none of the cold-storage article. Consequently, the meat you get at the table lacks that "ripened" quality of good refrigerated beef and has a certain tang that, in another two or three days, would be pretty close to spoilage—from our viewpoint.

Cold storage not only keeps seasonal foods in even supply through the year but makes for quality, because only the best can be stored that way. Whistler said there was no such thing as a tolerable egg. There isn't, in cold storage. An egg must be AA1 and XXXX to go into the refrigerators in May. If not, it will be intolerable when taken out six or eight months later. And that holds true of butter, fish, meat, fruits—everything carried over by this modern process of food storage. No silk purse out of a sow's ear here!

Last winter I had some grapes with a history. They ripened in the sunny town of Mendoza, on the western border of Argentina, and were picked and then hauled across the desert and pampa for about 48 hours to Buenos Aires. There, they went into the refrigerating compartments of a ship; and after nearly a month's steaming north, through the tropics, arrived at a New York pier. Loaded on a motor truck, carefully covered to prevent freezing, they reached the wholesale fruit dealer who gave me a couple of bunches. He examined them, decided they would bring a better price a little later, and put them in his own cold room in the cellar, which is kept at any temperature he pleases by ammonia gas piped from a central plant.

Talk about making the world smaller with radio and Zeppelins, if you want to, but do not forget how cold storage has shrunk continents, the old globe itself, so that New Yorkers can eat fresh California figs in summer; London can have South African peaches in February; and Argentine or Chilean grapes can be retailed in New York in mid-winter at 50 cents a pound.

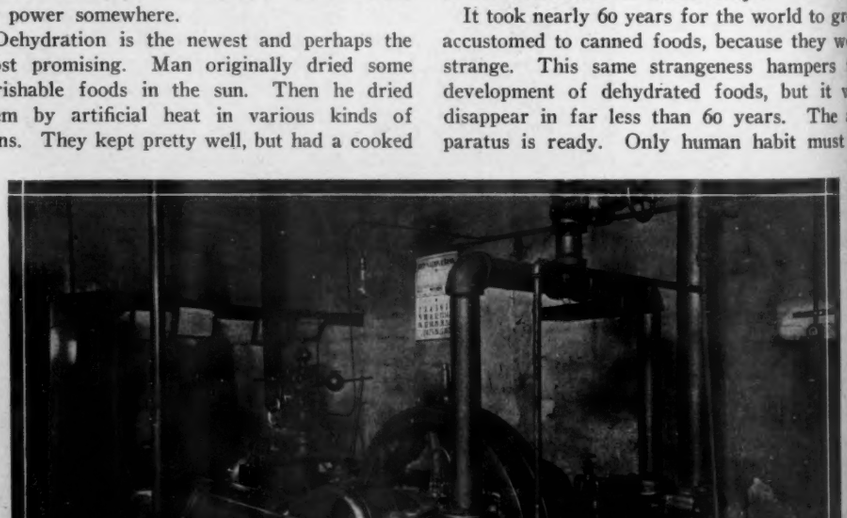
Until just yesterday, hardly 100 years ago, man had only three or four ways to preserve food, and the present generation turns up its nose at most of them. There was salting. Think of the present generation tolerating salt pork! And there were pickling, smoking, crude drying, preserving in sugar or fat. Canning, cold storage, and dehydration are the modern methods, and all three of them include air power somewhere.

Dehydration is the newest and perhaps the most promising. Man originally dried some perishable foods in the sun. Then he dried them by artificial heat in various kinds of kilns. They kept pretty well, but had a cooked flavor because the heat was too high or the drying too fast. Now, new processes of dehydration are being worked out by which gentle heat, in vacuum, extracts moisture from fresh foods without breaking down their cellular structure; or liquid foods are converted into dry powder by spraying them into heated air with compressed air. By gently drying fresh food in vacuum it is possible to turn a bushel of potatoes into ten or twelve pounds of chips, or a bushel of spinach into one pound of shavings. Soak them in water, and they "come back" absolutely fresh if dehydration has been skilfully done.

Our British cousins are fond of marmalade, for which manufacturers in the United Kingdom import orange peel, pickled in brine. By modern dehydration, however, they can get dried orange peel from California at a great saving in freight, with less danger of spoiling, and of markedly higher quality because it is more nearly like the real thing. Our British cousins are also large consumers of meat extracts, beef boiled down to meat essence and put into jars holding a few ounces. With good dehydration processes, this same beef can be cut into meat flakes, dried, and ground into beef flour. So can any kind of meat, poultry, and fish.

With the dehydration process that turns liquids into powder, just as surprising things are possible. Some of them are already being done on a large scale—such, for example, as the powdering of fresh whole milk, skim milk, and buttermilk. In the future may come things like taking the juice from a surplus crop of lemons in California, converting it into lemon powder, and shipping it anywhere in the world to make lemonade or lemon drops.

It took nearly 60 years for the world to grow accustomed to canned foods, because they were strange. This same strangeness hampers the development of dehydrated foods, but it will disappear in far less than 60 years. The apparatus is ready. Only human habit must be



This compressor provides operating air for a glass plant manufacturing tableware.

Courtesy Canning Age.

Air-operated hoists make quick work of charging and discharging steam kettles in which canned peas and other vegetables are cooked.

changed. When dehydrated food is as familiar as canned food the housewife will have on her shelves various small tins of dried chips which will, when soaked a while in water, come back as potatoes, cauliflower, string beans, prunes, pears, cherries—yes, and even meat, poultry, and fish.

Air power in the sugar bowl! For centuries, man used honey to sweeten his dishes; and then the art of boiling sugar from the juice of the cane was discovered. At first, the boiling was done in open pans, with waste in fuel and in juice. There was too much heat where the juice touched the pan, and the sugar got burnt. Heat was also wasted. In France, it took half a pound of coal to boil a pound of beet roots by the open-pan process. Then the simple vacuum can was substituted, and a quarter pound of coal did the same work. But the big thing in sugar boiling was still to come—the "triple effect" of Rillieux, a French inventor, who devised a process whereby the greater portion of the water in beet or cane juice was evaporated in a triple arrangement of vacuum pans, the steam from the boiling juice in the first heating the second, and that from the second heating the third. With the triple effect, in use all over the world today, the air giant has cut the ratio to less than two ounces of coal for a pound of beet roots. The three vacuum pans of the triple effect are connected with the vacuum pump in the final pan. As the juice thickens by boiling in the first pan it is drawn into the second, where the vacuum is higher. And, as it thickens still further, it goes into the third pan—the boiled juice being periodically drawn off and fresh juice drawn into the first pan. Besides saving fuel, this process avoids spoiling the sugar by burning.

In other days, dinner might have been preceded with whiskey and soda. Even now, a cool drink made with fruit juice and mineral water is refreshing. Quite an imposing array of beverages, not to say real foods, have grown out of the Seltzer siphon. Considerably less than 100 years ago, so the story goes, carbonated drinks were unknown. A Philadelphia physician thought that water charged with carbon-dioxide gas would be beneficial to patients suffering from digestive troubles. He and a Philadelphia druggist put their heads together and invented soda water; and presently Quaker City "fashionables" were flocking to the drug store for their nip of soda pop. They liked it, and eventually people with perfect digestion were drinking this "medicine" for its fillip. In the course of time, somebody invented ice-cream soda. It has never been definitely settled who gave this splendid heritage to the nation, as ice-cream soda and many of the fruit drinks served at fountains have real food value. Where once wise doctors scolded people for patronizing the soda fountain, now they admit that popular instinct was right, as it often is in these matters.

Behind the "s-s-s-s-s" of the soda fountain or the Seltzer siphon there is a pressure of from 100 to 120 pounds per square inch. Bacteria puts the bubbles into champagne; but for these artificially charged liquids, marble dust and sulphuric acid are combined to produce carbon dioxide which, after being scrubbed clean, is introduced under pressure by charging machines into tanks for soda fountain use and is also employed for ginger ale, pop, and other carbonated drinks. And the siphon or pop bottle, itself, is nowadays made by air power, because the lungs of the glass blower have been replaced by marvelous bottle-making machines!

Air power on the dinner table is still in its babyhood. Eventually, it may prove to be as basic a giant in the preparation, delivery, and serving of our daily bread as the giant, heat.

HOLDING POWER OF NAILS

THE Forest Products Laboratories of the Department of the Interior of Canada is conducting a series of very interesting experiments having to do with the holding power of nails. So far some 600 tests have already been made; and the work is to be continued until definite data is obtained bearing on the sizes and the types of nails to be used for certain purposes and for certain kinds of wood, such as are employed in the Dominion.

These investigations should prove of value to the woodworking industry, as a difference of, say, half an inch in the length of a nail may mean an appreciable saving where large quantities of nails are used. The cut nail has greater holding power than the wire nail, but is not as easily driven. However, when cement coated and barbed, the holding power of the wire nail is considerably increased.

The food bill of the United States totals $15,000,000,000 annually.

Type of compressor which provides air for bottle-blowing machines in a large glass plant.

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EDITORIALS

TRIBUTE TO THE JACKHAMER

THE profitable productiveness of the gold mines of South Africa is undeniably largely due to the substitution of mechanical for the more laborious manual methods of drilling the rock carrying the precious metal. One of the most progressive of the companies in that field published in its last annual report this significant paragraph: "The equipment of the mine with jackhamers is now almost complete, and their introduction has resulted in a material reduction in the cost of breaking. The cleaner mining possible with these machines, and increased sorting, have improved the mill grade, and this, together with the increased tonnage crushed, has resulted in a larger profit."

Regarding the improvements brought about by the introduction of this handy and efficient rock drill, the *South African Mining and Engineering Journal* comments upon a memorandum, read not long ago by SIR EVELYN WALLERS, which dealt with the development of the use of jackhamers. SIR EVELYN "pointed out that one of the outstanding items of the improvements in efficiency in rock breaking was the development of jackhamer methods for stoping work. It became a factor in stoping operations about the end of 1916. Inadequacy of native labor for hand drilling compelled the increasing use of rock-drilling machines for stoping purposes, whether the physical conditions of the stopes were suitable for their economic use or not. The jackhamer, as reintroduced, promised some relief, in that it would do work more or less on the basis of hand drilling, and thus better suit the physical conditions while reducing the native labor requirements. Despite the fact that economic benefit from their use was very much in doubt, they were used in increasing numbers. Small improvements were obtained from time to time, but the rooted prejudice of the miners to any alteration in methods of operating machines effectively blocked progress until after the 1922 upheaval. During 1920 and 1921 systematic experimental work on definite lines was in progress, and this work demonstrated that in the operating time the same jackhamer would do about twice as much as was being got out of it in ordinary practice. By using smaller bits, carefully shaped and tempered, and by passing the water supply through the steel, the drilling rate was nearly doubled and the dust created was lessened appreciably."

Further, we are informed: "The safety of the underground workings was materially improved with the use of jackhamer methods. Not only was the stoping width better controlled and usually reduced, but the hanging wall was less shaken by the smaller charges and there was less damage to the supporting packs. This meant less work in keeping places safe. Moreover, with the greater amount of work done with each machine, there were fewer risks and fewer machines and hoses about to interfere with clearing out the broken rock and putting in roof supports."

CONSUMPTION OF FUEL OIL BY STEAM LOCOMOTIVES

ACCORDING to returns received from railroads by the American Petroleum Institute, steam locomotives on those lines in the United States consumed a total of 63,206,034 barrels of fuel oil during 1924, compared with 58,005,295 barrels in 1923.

Explaining further, it seems that the total consumption in 1924 was made up of 51,251,563 barrels of domestic fuel oil and 11,954,471 barrels of Mexican fuel oil, while the 1923 consumption was made up of 46,407,231 barrels of domestic oil and 11,598,064 barrels of Mexican oil. The largest consumption of fuel oil for this purpose was in the Middlewestern and Southwestern districts—totaling 32,651,547 barrels in 1924, of which substantially two-thirds were from domestic sources and one-third from Mexico.

The fact to be kept in mind is that the use of fuel oil on so large a scale was inspired by a desire to effect savings in cost of operation while maintaining a higher standard of performance than would have been possible if coal had been burned instead. This is an interesting object lesson in railroad economics, and reveals a wider utilization of fuel oil on railroads than is generally known. The inference to be drawn from this disclosure is that the railroads, like other large users of power, will eventually turn to the oil engine as a substitute for the steam engine; and, in anticipation of this prospective demand for something still more efficient and economical, engineering concerns of long and wide experience have brought into being the oil-electric locomotive.

AT THE CROSSROADS OF TECHNICAL TRAINING

IN his annual report, DR. THOMAS S. BAKER, president of the Carnegie Institute of Technology, points out forcibly how the trend of industry is changing the demands made upon the engineer, and he emphasizes the need for educational changes which will make the trained technicist better fitted to meet the responsibilities that will inevitably be placed upon him in the future. As Doctor BAKER mentions, the modern tendency in manufacture is toward centralization and standardization; and this virtually means that more will be expected of engineering executives in the way of organization and administration than has been generally the case heretofore.

The ever-widening applications of machinery in industry and the corresponding lessening of manual skill in the average worker have their reflex in many departments of any great manufacturing plant; and more and more both the worker and his superiors have grown somewhat standardized, one might almost say "machinized" in their attitude towards their respective tasks or offices. This is the trend of the times, and the utmost care is needed in the training schools and colleges to see to it that initiative and talent shall be fully encouraged even though a factory must now be more intimately coördinated, each department more closely identified with the movements of all the others, than has been the practice in the past.

To quote Doctor BAKER: "The engineer reflects more completely the spirit of the age than the member of any other profession. He is the creation of an industrial civilization, and his career and his livelihood are dependent upon the course that it follows. So in considering what his training should be we are justified in trying to forecast the lines that industrial development will follow. I think it is clear that in the future industry will require men of great originality, initiative, and professional skill to create the products which will be manufactured in large quantities. This will be strictly engineering work, but the number of such men who will supply the technical direction for their concerns will not increase in proportion as business organizations grow in size and as they limit the variety of their output. On the other hand, the demand for organizers, administrators, executives of various grades, and salesmen will increase.

"The technical schools have, therefore, a twofold task. They must strive to train and to develop engineers who will do creative work in the industries, who will supply the motive power for industrial progress. This will be a grateful task, but presupposes high-grade

students and ample time for their preparation. The easier and bigger opportunity for the college is to train men who will fill the ranks of the great army of industry, but who cannot be originators or do engineering work except in a limited degree. If we want to serve the greatest number we must broaden our courses: if we want to train men who are to be real engineers, we must intensify and, possibly, lengthen our courses. In time, educational institutions may restrict themselves to one or the other of these lines of work."

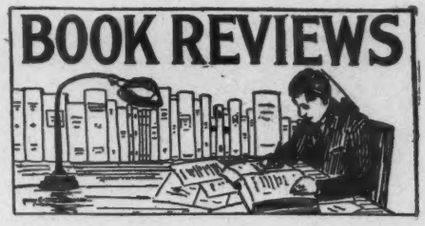
BELITTLING US

WE were all set up a bit a few weeks back when it was announced that Dr. JOHN F. HAYFORD, head of Northwestern University College of Engineering, had definitely established the equatorial and the polar diameters of the earth—his figures showing that the girth at the equator was about a mile greater than had been recognized previously by the scientific fraternity. That addition took on something of the significance of the traditional half inch placed on the end of one's nose. In short, we felt that we were living in a larger if not a more pretentious world. But our sense of amplified importance scarcely lasted over night.

Measurements then just completed at the Mount Wilson Observatory disclosed that the hitherto premier star, Betelgeuse, was outclassed by another star, Mira, which had so long appeared as little more than a luminous speck in the firmament. Betelgeuse has been superseded in size by a heavenly body apparently 25 per cent. larger; and, according to the interpretations of that exquisitely delicate instrument the interferometer, Mira can boast a diameter of 250,000,000 miles. The best that we can offer in the way of diminutive contrast is a trifling matter of 7,926.68 miles from point to point on opposite sides of our equator! The remoteness of Mira is made appreciable when we are reminded that the light we see coming from her today started on its journey 165 years ago, and has been traveling ever since at the rate of 186,000 miles a second. No wonder, in sheer desperation to bolster up our self conceit, terrestrial scientists have been busy determining the size of the atom; and it is comforting to know that 100,000,000 of these can be placed side by side in the space of an inch.

CONGO IS NOW GREATEST COPPER PRODUCER

THE year in copper, so we are advised by *Commerce Reports*, was marked by the ascendency of a new producing area outside of the American continent. The great property of the Union Miniere du Haut Katanga, Belgian Congo, Africa, has forged into first place as a copper producer—its monthly output now ranking greater than that of any other single mine. Future production will be still heavier if present metallurgical plans are carried out. Other new African deposits of copper are also reported. With the increasing world demand for this metal the African production is not dislocating the industry to any decided extent.



CZECHOSLOVAKIA, edited by Dr. Josef Gruber, Professor of Economics at the Charles University in Prague. A work of 256 pages, published by The MacMillan Company, New York City. Price $2.00.

THE political upheaval in Europe in October of 1918 brought about the establishment of Czechoslovakia as an independent state; and the present volume is a survey of the economic and the social conditions of this newcomer among the republics of the world. A number of the leaders of Czechoslovakia have united in telling the story of her resources and her problems. The book contains a wealth of useful and authoritative data, and should be very helpful in promoting a better knowledge and a sympathetic understanding of a very admirable people.

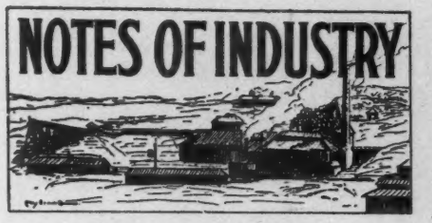
BUSINESS—A PROFESSION, by Louis D. Brandeis, Associate Justice of the United States Supreme Court. A work of 374 pages, published by Small, Maynard & Company, Boston, Mass. Price, $3.00.

IN its original form this book was published eleven years ago, and because of the value of its informative pages a revised and enlarged edition is now offered the public. For decades, many decades, a business career has been commonly considered in the light of a pursuit rather than in that of a profession. Men grew up in it because barter and sale seemed to appeal more to them than book learning; and when a merchant succeeded his success was attributed to the possession of a distinctive gift described, in lieu of something better, as "business sense."

Justice Brandeis throws a very different light upon business as an aspect of a people's social and economic life; and the illumination brings out sharply the kinship between the professions, as we understand them in a restrictive sense, and business as certain fields of endeavor are classified. The author says: "Each commencement season we are told by the college reports the number of graduates who have selected the professions as their occupations and the number of those who will enter business. The time has come for abandoning such a classification. Business should be, and to some extent already is, one of the professions. The once meagre list of the learned professions is being constantly enlarged. Engineering in its many branches already takes rank beside law, medicine, and theology. Forestry and scientific agriculture are securing places of honor. The new professions of manufacturing, of merchandising, of transportation, and of finance must soon gain recognition. The establishment of business schools in our universities is a manifestation of the modern conception of business."

BLUEBOOK OF SOUTHERN PROGRESS, 1924. A volume of 153 editorial pages, published by Manufacturers Record, Baltimore, Md. Price, $0.50.

THIS annual is an authoritative summing up of the progress that is continuing undiminished in that group of states commonly spoken of as the South. The advance taking place there is little less than amazing; and the section's natural riches and the energy of its aroused people give assurance of well-nigh measureless potentialities. The bluebook contains figures that bear indisputable evidence to what has been accomplished and suggest something of what the future has in store for this part of the United States.



The longest railway route in the world is not in either of the big continents, where we would naturally look for it. From London to Constantinople is 2,277 miles, including the Channel crossing; from San Francisco to New York is 3,169 miles; and from Vancouver to Halifax is 3,622 miles. By the recent completion of a connecting line, a continuous railway route, 5,433 miles long, now extends from Meekatharra, in Western Australia, to Dajarra, in Queensland.

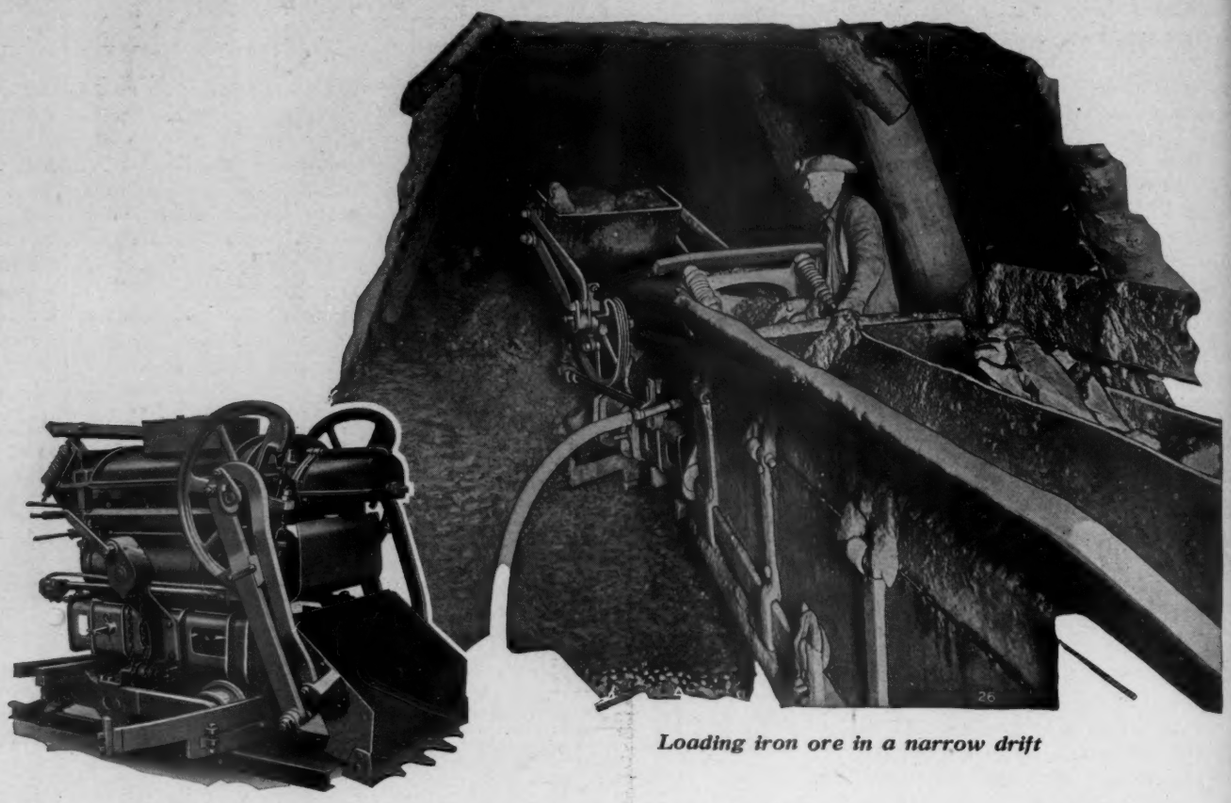
The per capita consumption of ice cream in the United States in 1924 amounted to 2.56 gallons. Expressed differently, our manufacturers produced last year a total of 285,550,000 gallons of this delectable foodstuff.

The most powerful lighthouse in South America was recently put into service. It is located on the Island of Rincon, about twenty miles to the south of Bahia Blanca; and its light, which is of 20,000,000 candle power, is visible for a distance of 36 miles.

According to the latest figures, one-sixth of the electrical energy now developed in Canada is being used in the United States.

The International Petroleum Company, of Colombia, South America, is planning to construct a pipe line reaching from tidewater to its oil properties about 350 miles up the Magdalena River.

For the first time in history, wireless communication was recently maintained between airships in flight. The 'planes were both equipped with broadcasting and receiving instruments; and it is said that the pilots conversed freely while their machines were more than five miles apart and traveling in opposite directions. The feat was accomplished at Wilbur Wright Field, Dayton, O., while testing new radio equipment.



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Our SHUVELODER Department will gladly send you further particulars regarding the application and cost reducing possibilities of this machine. Bulletin DR-7 sent upon request.

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